AIRCRAFT & MISSILES

A Chilton Publication APPLIED ENGINEERING FOR THE AEROSPACE INDUSTRIES November 1960

Electronic Materials Report—Microcircuitry...P 43

WE TRIED TO DO BUSINESS WITH DOD . . . P 51

Bootstrapped Boosters Spell Simplicity In Titan...P 56

SPECIAL REPORT . . . HONEYCOMB

A Hot Market For Hot Structures . . . P. 17

expect greater ACCURACY from KAVLICO TRANSDUCERS

The experience of Fred Kavli,
who designed these transducers,
is available to you.

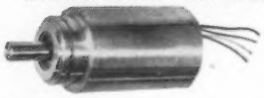
KAVLICO CONVERTER TRANSDUCER Model GM-9026

Input Voltage: 6V to 25V 400 CPS
Output Voltage: 0 to 5V DC (Polarity reversed at Null position)
Threshold Sensitivity: .0001% of full range
Linearity: Within 2% over ±¼"
Temperatures: −320°F to 250°F
Vibration: To 35 g's; to 2000 CPS

TYPICAL APPLICATIONS: telemetering of displacement; general laboratory purposes; as sensor in scales, material test machines, flow meters, machine control, etc.

OTHER CONVERTER TRANSDUCERS with features such as: 500V D.C. output per inch displacement; .05% Linearity; strokes up to 15"; various sizes and mechanical configurations.

KAVLICO ROTARY TRANSDUCER Model GM-9060



Linearity: ±½%
Output: 5V full scale
Input: 26V 400 CPS
Resolution: Infinite
Phase Shift: 5° max.
Rotary range: GM-9060A ±90°
GM-9060B ±180°
GM-9060C ±360°
Temperature range: −65°F to +300°F
Vibration: To 35 g's; to 2000 CPS

Used as feedback transducers for rotary actuators, valves, machine control, various aircraft and missile applications.

Other angular position transducers are available on special order with full scale displacements of ±40° to ±10 revolutions and temperature range from −65°F to 600°F.

KAVLICO VELOCITY TRANSDUCER Model VT-8-3.5

Housing length: 3.5"
Linear range: .7"
Output: .1 V/in/sec.
Diameter: .500"
Linearity: ±1%
***No excitation required.**

Other velocity transducers provide: 1 V output per inch, per second; stroke up to 15 feet.

Provides: a D.C. ouput signal proportionate to velocity of linear motion of core; velocity feedback signal for servosystems; direct measurement of velocity of movement with increased accuracy and simplicity.

LINEAR DIFFERENTIAL TRANSFORMER Model GM-8013 TEMPERATURE COMPENSATED

Input: 26V 400 CPS
Stroke: ±.7"
Linearity: 1%
Output: 8 Volt/inch @ 26V 400 CPS input
Change in gain over temperature range: .005%/°F.
Temperature range: −65°F to +300°F
Vibration: To 35 g's; to 2000 CPS
Housing Length: 4"
Housing Diameter: ⅜"

Other models with shorter and longer stroke available. Most extensively used in actuators in missiles and aircraft to provide feedback signal for servosystems. Models have been designed and are available for 5Kc square wave excitation.

KAVLICO VARIABLE RELUCTANCE TRANSDUCER Model RA-3-6-1.5

Stroke: .5"
Linearity: .5%
Output: 1.2 V/in/V
Input: 10V 3000 CPS
Temperature: −65°F to +300°F
Housing Length: 1½"
Housing Diameter: ⅜"

A complete line of variable reluctance transducers available with linearity of up to .03% and strokes up to 8.5 inches. Some models will operate at 1000°F continuous duty and 1200°F intermittent duty. Used extensively for measurement.

linear displacement • angular position • velocity • torque force • pressure

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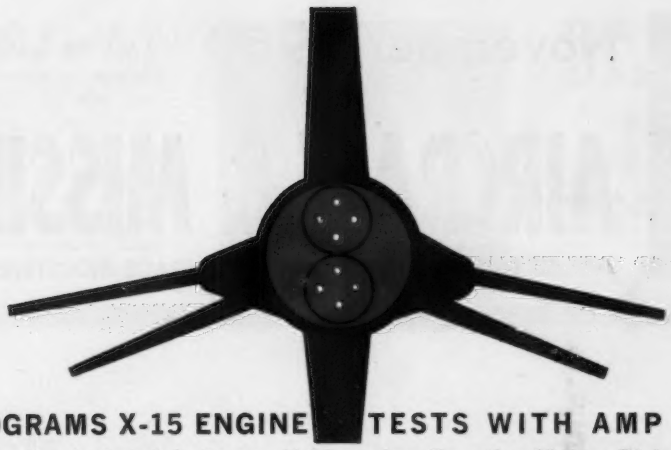
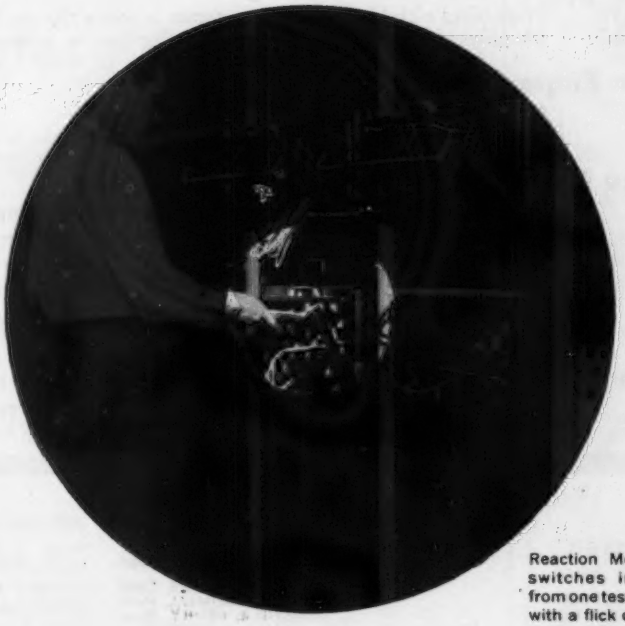


Thiokol PROGRAMS X-15 ENGINE TESTS WITH AMP PATCHBOARDS

To test the 50,000 pounds of whoosh in its new X-15 engine, Reaction Motors Division of Thiokol Corporation required versatile and reliable programming systems to connect instrumentation to six different test stands. With the assistance of AMP engineers, Thiokol installed six patchboard programming systems that can connect one set of test instruments of any of six test stands with a flick of the wrist—a saving of time, personnel and equipment. In addition to tremendous flexibility, AMP systems—either universal or shielded—provide a number of exclusive features including pre-cleaning of contact pins and springs, rugged take-a-beating construction, an almost unlimited range of sizes, plus electrical characteristics suited to the most sensitive applications—all contributing to top notch reliability. **For the complete story, write for our Patchcord Programming Catalog.**



Reaction Motors' technician switches instrumentation from one test stand to another with a flick of the hand.

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November, 1960 *Volume 3, Number 11*

AIRCRAFT & MISSILES

APPLIED ENGINEERING FOR THE AEROSPACE INDUSTRIES

Features

PAGE

17 **Sandwich Structures . . . The Status and The Outlook**
Big market just ahead for brazed stainless honeycomb;
Refractory metals, ceramics, welded stainless figures in future

21 **GSE For The Minuteman**
From plant to silo, Boeing has integrated
ground-support equipment into weapon-system design

28 **How X-15's Engine Is Made Safe**
Igniter is key component in XLR-99 design;
Lights off in two stages, prevents accumulation of unburned propellants

37 **Bristol Type 188 Aircraft**
Designed for supersonic research; Features all-steel structure

38 **Working René 41 Into Your Design**
High-temp nickel-base alloy now comes in many standard forms;
Mounting know-how is increasing applications in aerospace hardware

43 **Molecular Engineering For Electronics**
Small components built up molecule by molecule;
Future unitary electronic-structures may pack thousands of individual components

46 **Aerospace Demands Spur Brazing Advances**
Liquid-rocket chambers speed development in high-temp joints;
Five basic designs bank heavily on brazing

51 **We Tried To Do Business With DOD**
Does ASPR IX make it legal for the Government
to pick brains of small R & D firms and hand data to competitors?

56 **Simplifying Titan Engines Ups Reliability**
Aerojet's design philosophy eliminates engine "service systems,"
favors "bootstrapped" controls actuated directly by fuel pressure

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Departments

PAGE		PAGE	
5	Editorial	61	New Electronic Products
7	Reader's Orbit	63	New for Production
9	Datebook	65	New Materials
11	Data Capsule	67	New Parts and Components
13	The Aerospace MAP	72	Worth Asking For
15	New Books	74	Men on the Move

Industry Notes

PAGE		PAGE	
75	The Courier Capsule	78	Escape System
76	R & D Briefs	78	Satellite to Hold Several Hundred Men
76	Production Techniques	79	Braking the JetStar
77	Brazing Tungsten	79	Need Metals Data?
77	Material Requirements For Dyna - Soar Type Re-entry Vehicles	80	GTOL Concept Studies

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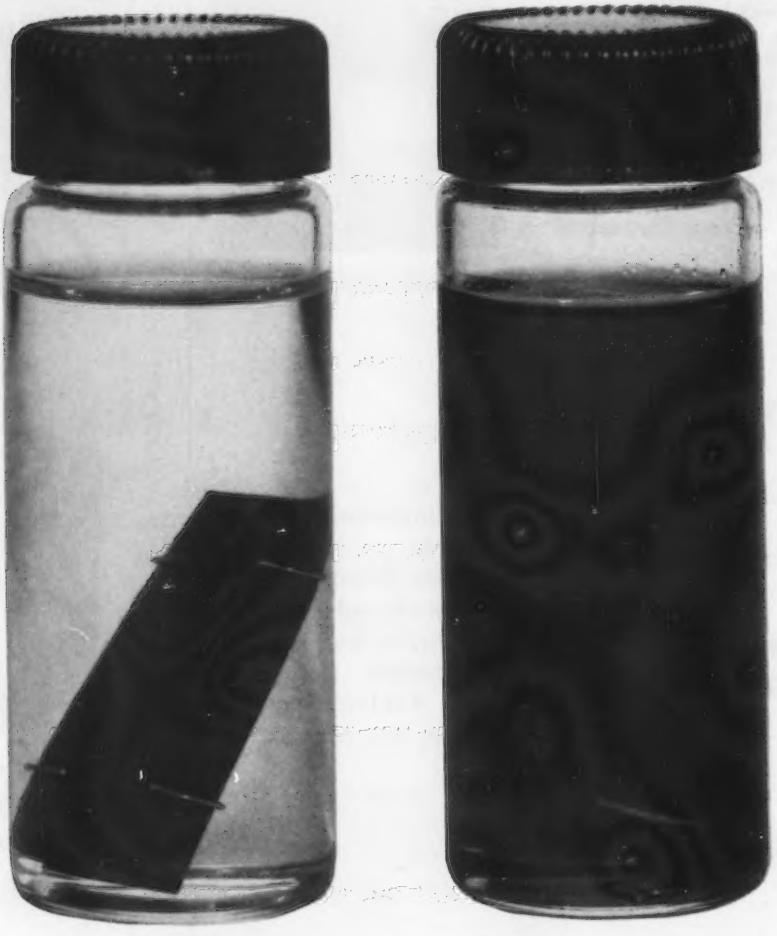

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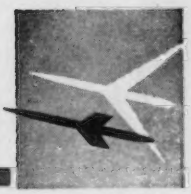

Wanted: A Defense Against DOD

Is our biggest customer, DOD, spending our money and becoming a dictator at the same time? Are its procurement policies confused? You be the judge after looking over the following statement by Perkins McGuire, Assistant Secretary of Defense, Supply and Logistics.

In a letter to Senator George Smathers, chairman of the subcommittee on government procurement of the select committee on small business, Mr. McGuire stated, ". . . it does not seem right for us to make a regular practice of deliberately infringing patents where we already have adequate capacity to meet defense needs. If, in a given case, we concluded that the best interests of the government required that we do so, as, for instance, where we were being charged clearly excessive prices, we could authorize infringement in a formally advertised procurement. Negotiation authority would not be required for this purpose. Obviously, if the restriction of sources stems from the existence of trade secrets, negotiation authority would not help us. We would not have access to secrets in any event."

From all the evidence that Aircraft & Missiles has obtained over the past several months, it certainly appears that we do not have adequate defense capacity. If we did, certainly there would be no infringement of patents or proprietary rights—by Mr. McGuire's statement.

Further, just to make infringement legal, someone seems to decide that excessive prices are being charged by certain companies. Who decides excessive prices—your competitors, or perhaps someone completely unrelated to the cost structure of the firm producing the product?

Then, there's the real joker in the final two sentences. If you can't negotiate the trade secrets out of a company, then, evidently, DOD can make the firm give up the ghost by declaring inadequate capacity or high prices.

Certainly seems as though the squeeze is on from both ends. Sort of like the friendly dictator, sweet talks you while a big stick is held over your head.

Well, what are you doing about it? Little business can't do it alone and neither can big business. But, you can fight for fair treatment if you join hands. How about letting your employees know that their jobs could be in jeopardy under some of the DOD procurement practices?

Tom MacNew
Editor

light weight

airborne strength..like a

TITANIUM

Huckbolt* Fastener!

Strength to span oceans without a gram of needless weight. Dependable strength at elevated temperatures. Greatest structural integrity. Positive swaged lock. These are only a few of the features which recommend these outstanding fasteners for your use.

Maximum strength maintenance with almost fifty percent saving in installed weight is an accomplished fact.

Titanium Huckbolt fasteners are available in tension or shear types, countersunk or protruding heads and in pin diameters and grip lengths as desired.

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Reader's Orbit

A Device Exists?

. . . In your July, 1960 issue, the leader for the article by Mr. Walter S. Wilson "Man-Machine Space Complex" states firmly: "Effects of weightlessness pose biggest question mark. No device exists for earth-bound tests at zero gravity." We should like to enter an important correction to the latter half of that statement. Lockheed's Georgia Division has nearly completed the construction of a "Null-Gravity Simulator," a device for the simulation of the state of weightlessness in the human subject for many hours and even days at a time. The psychological and physiological effects of null- or zero-gravity on the human being are expected to be so well reproduced by this artificial environment that a wide-ranging series of tests on tolerance to weightlessness and the cumulative results of being in such a state for long periods of time may be studied, well in advance of the establishment of orbiting laboratories.

The device is designed to nullify all of the important sensory cues to the existence of a gravitational field: visual, mechanical, and inner-ear balance cues are to be reduced to negligible levels. In addition, physiological effects of weightlessness on the cardiovascular system, the body musculature, and load-bearing bony structures will be reproduced in this environment.

If you feel your readers would be interested in such an approach to the problem of long-term weightlessness, we would be happy to submit a paper for publication in your magazine. 'In any event, we would be interested in seeing the impression that nothing can be done about the problem, which was left by the referenced article, amended to cover this new approach.

Lee Rogers
Director, Public Relations
Lockheed Aircraft Corp.
Georgia Division
Marietta, Georgia

We shall be pleased to consider a paper dealing with Lockheed's "Null-Gravity Simulator" project for publication in a future issue of Aircraft & Missiles.

Numerical Control

The article on Numerical Control in your September issue was read with great interest here . . . I would appreciate a reprint . . .

How can we obtain copies of your magazine on a continuing basis . . . It is of interest in our Numerical Control Section.

L. G. Kauffmann
Production Engineer
Tool and Fabrication Planning
Aerojet-General Corp.
Sacramento, California

Considerable interest was shown in this subject by our readers. The aggregate of individual readership-response letters assists the editorial staff in measuring the usefulness of the material presented.

Go Discoverer Go!

Just finished my first copy of Aircraft & Missiles and enjoyed it very much. I was especially interested and pleased to see the article concerning the Discoverer Satellite program.

With the excellent success on Discoverer Thirteen and Fourteen we feel that everything should go go from now on . . .

Congratulations again on a fine and authoritative publication.

Kenneth E. Parker
Inspector, Missiles & Sys.
Vandenberg Air Force Base

Too Many Inquiries

I don't know how these things happen, but they happen. You will note in the September issue of Aircraft & Missiles that our organization, the Curtis Winters Company, is engaged in the design and manufacture of static inverters. Of course, we could handle all these inquiries and obtain these units on a private brand basis from the client, Arnoux Corporation, but this would be a little bit awkward.

Curtis R. Winters
President
Curtis Winters Co.
1263 Westwood Blvd.
Los Angeles 24, Calif.

We regret the transposition of names between agency and client. Static inverters are manufactured by the Arnoux Corporation, not by the Curtis Winters Company.

Wanted For Briefing

It is requested five copies of the article "Cryogenic Hydrogen Progress" (October) be forwarded to this office to be used for briefing purposes.

Legrand W. Burt
Major, USAF
Deputy Chief, Centaur Division
Headquarters
AMC Ballistic Missiles Center
United States Air Force
Los Angeles 45, California

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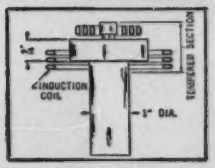
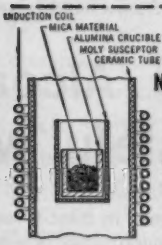
TYPICAL INDUCTION HEATING APPLICATIONS



Punch Heads Selectively Tempered

Diagram shows arrangement for selectively tempering heads of alloy steel punches. The use of a combination type solenoid and pancake induction coil reduces hardness from Rc 55/56 to Rc 41/44, improving resistance to brittle fracture at the head of the punch. In this case a heating cycle of 55 seconds provides uniform tempering. A multiple position fixture, processing 4 pieces at one time, speeds up production.



Heating Non-Conducting Materials To High Temperatures

Laboratory analyses frequently require heating of non-conducting materials to temperatures of 3,000 to 3,500° F. in vacuum or special atmosphere. This can be accomplished by induction heating with the aid of a metal susceptor. Diagram shows the fusion of mica samples in an alumina crucible, using molybdenum susceptor. A ceramic tube surrounding the susceptor isolates the work for fusion in a vacuum. The molybdenum susceptor is heated by induction, which in turn, heats the crucible by radiation.

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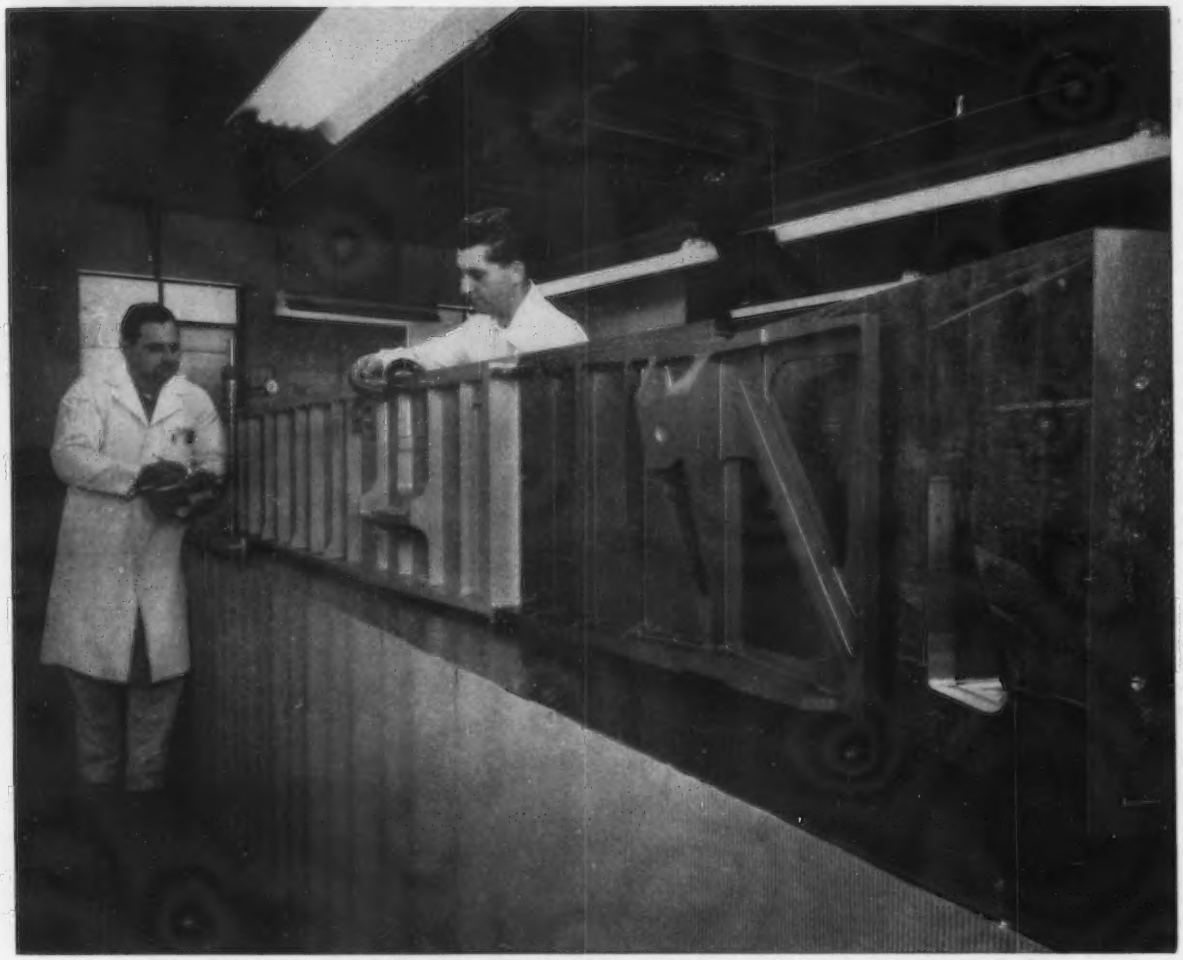

Automation Industries, Inc., machines this complex wheel-well bulkhead for the Convair B-58 from a hand-forged, stress-relieved, ultrasonically inspected slab of 7079-T651 Alcoa® Aluminum.

Alcoa stretches aluminum to cut wasteful warpage for Automation Industries

Residual stresses in heat-treated parts can cause problems during machining: bowed parts, difficult straightening, extra machine setups. Stretching hand forgings (companion Alcoa development to compressive stress-relief) "relaxes" them, can relieve internal stresses even better than compressing.

MID-CONTINENT Division of Automation Industries, Inc., needs 12-ft aluminum forgings with a maximum of stress-relief. From each half-ton slab, Mid-Continent precision-machines 78-lb wheel-well bulkheads for Convair's B-58 Hustler. Bow tolerance: 0.001 in./in.

TO SUPPLY the stock for this part, Alcoa stretches 4¼ x 23½ x 144-in. billets a carefully controlled amount, right after heat treating. Almost two decades of experience in stretching for stress-relief have proved subsequent warpage is reduced an average 95 per cent. Alcoa inspects each slab ultrasonically before shipment to the customer.

REMOVING 94 per cent of the metal in a series of extremely precise operations, Automation Industries doesn't even have to clamp Alcoa forged billet down. It's so free of residual stresses that vacuum is enough to hold it throughout lengthy machining. For all practical purposes, warpage and expensive straightening are eliminated.

Alcoa has been stress-relieving aluminum by stretching, compressing and other processes longer than anyone else, but we're not relaxing ourselves. Even though we now can supply stress-relieved forgings, sheet, plate, extrusions and rolled parts, intensive research continues on new and improved methods. For technical help, call your nearest Alcoa sales office, or write Aluminum Company of America, 2032-L Alcoa Building, Pittsburgh 19, Pennsylvania.

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Sheraton-Park Hotel, Washington, D. C.

November 2-4
Tenth Aircraft Hydraulics Conference
Vickers Inc.
Pick-Fort Shelby Hotel, Detroit Mich.

November 8-11
First National Die Casting Exposition & Congress
Society of Die Casting Engineers
Detroit Artillery Armory

November 11-12
Quality Control and Reliability Conference
American Society for Quality Control, Middle Atlantic Region
Lord Baltimore Hotel, Baltimore, Md.

November 14-16
National Convention
National Aeronautics Assn.
Indio, Calif.

November 15-16
Mid-America Electronics Conference
Institute of Radio Engineers
Hotel Muehlebach, Kansas City, Mo.

November 15-17
36th Meeting
Aviation Distributors and Manufacturers Assn.
Riviera Hotel, Palm Springs, Calif.

November 15-17
Propulsion Systems Lubricants Conference (Air Force-Navy-Industry)
Wright Air Development Div., Southwest Research Institute
Hilton Hotel, San Antonio, Tex.

December 5-8
15th Annual Meeting and Astronautical Exposition
American Rocket Society
Shoreham Hotel, Washington, D. C.

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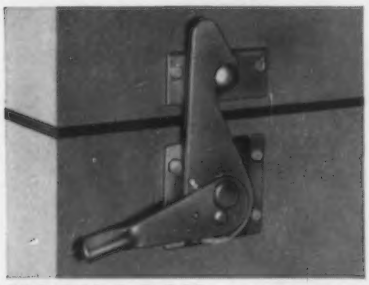
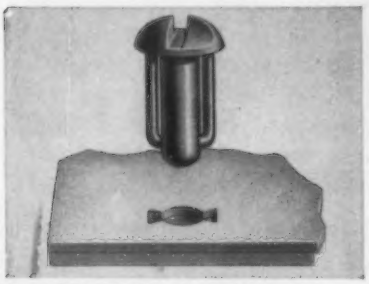
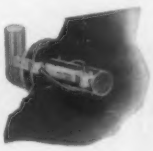


HOOK-LOCK–Springless, positive-locking latch which lies flat against mounting surface, open or closed. Provides high closing pressure and load-carrying capacity. For military as well as commercial container applications.

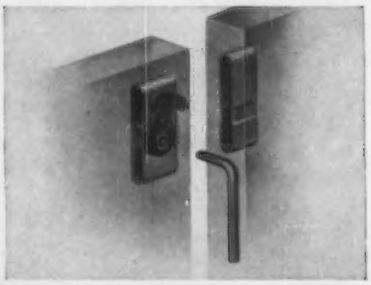


SPRING-LOCK–Perfect, proved blind rivet for removable covers and panels on electric and electronic equipment, sheet-metal automobile parts, appliances.

Plastic Spring-Lock Shelf Supports with "heart of steel" help refrigerator makers cut costs, speed production, simplify servicing.



LINK-LOCK–Ideal latching device where heavy locking pressure is necessary. Available in heavy, medium, light duty, for use in military and commercial containers and demountable construction.

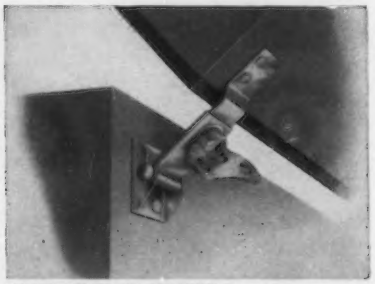


DUAL-LOCK–Impact and vibration-proof high-load butt-joint fastener that will not accidentally unlock or loosen. Recess in panels or surface mount. Withstands 7000-lb. tension.

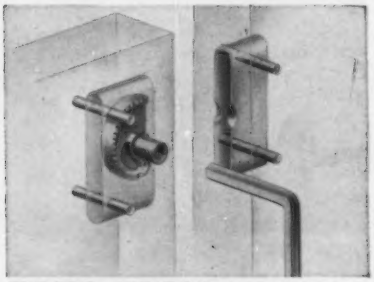
QUICK-LOCK–For assembling removable panels and access doors. Locked by a 90° turn. Various sizes and types, for weather-tight electrical units, cowlings, access panels.

LINK-LOCK

HINGE-LOCK



HINGE-LOCK–A rugged pressure hinge which provides a strong seal along the hinge line of gasketed equipment containers and transit cases. Matched hardware with LINK-LOCK.



ROTO-LOCK–Versatile fastener for butt or right-angle joints in portable shelters, partitions, knock-down shipping boxes, etc. Solidly built, springless.

CLAMP-LOCK–A simple and strong, positive-locking clamp for fast assembly (and disassembly) of permanent or temporary rooms and buildings of flanged-panel construction.

SEND TODAY for your copy of the Simmons catalog, with specifications, applications, installation instructions for all Simmons Fasteners. Samples are available. For special assistance, describe your requirements.

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See our condensed catalog in Sweet's Product Design File

Data Capsule

SUMMARY OF MANAGEMENT TRENDS AND TECHNICAL DEVELOPMENTS IN THE AEROSPACE INDUSTRIES

MISSILES AND SPACE VEHICLES

Design

INITIAL SKYBOLT DESIGN is almost finalized; midsection has phenolic nylon tape over an aluminum frame. Nose is high-pressure-molded phenolic. Skybolt reportedly is to be ready for use with B-52's by 1964.

HOT GAS INJECTION may steer advanced Polaris missiles. This method may get the nod over swivelling nozzles or present jetavators.

Development

FIRST ASTRONAUT FLIGHT, a 200-mile hop in a Redstone, may come in February. This capsule will carry a beryllium heat shield. Ablative shields will be used on all other capsules in program.

ASTRONAUTS' PRESSURE SUITS now have the "bio-patch" at the right thigh rather than waist. Bio-sensors will carry vital data through this on temperature blood pressure, respiration rate, electro-cardiagram.

NEXT STRATOLAB TEST, probably in June, will bear at least two men in a gondola for extended high altitude studies. New instrumentation in the Navy test is to include a small transmitter on each man. These transmit physiological data while the men move around. The Navy cites definite applications for future satellite laboratories.

SATURN BOOSTER slated to begin second series of static tests this month.

BULLPUP B is reportedly planned by the Navy, which is said to be studying large liquid prepacks for this missile. Bullpup A will be added to the armament of the F-105.

SPECIAL PENTAGON OFFICE has been established to manage the Samos reconnaissance satellite program.

SATAFS now command on-site work on Atlas and Titan bases. These "Site Activation Task Force Commanders" are senior Air Force colonels who report directly to the commander of the Ballistic Missiles Center, Air Material Command.

FLUORINE-HYDROGEN ROCKET ENGINE has been fired in full-scale tests at Bell Aerosystems Co. Liquid fluorine is the oxidizer. Liquid hydrogen is fuel.

FIRST MIDAS PAYLOADS have been delivered to the Missiles-Space Div., Lockheed Aircraft, by Baird-Atomic, Inc.

DYNA-SOAR CURRENT THINKING reportedly envisages flight tests in three stages: dropping a powered model from a B-52; boosting an unpowered model to suborbital missions by means of a modified Titan; and, finally, boosting a powered version to orbital missions by means of Saturn. Engine manufacturers are clamoring for the powerplant job. XLR-99, the X-15 powerplant, has been proposed both for the initial and the Saturn-boosted versions.

BMEWS STATION at Thule, Greenland, is now operational.

OPERATIONAL PROTOTYPE of Titan unit is now ready at Vandenberg AFB.

TOP FIBER-RESEARCH EFFORT will center on expandable, heat-resistant deceleration devices for advanced orbital craft. Devices would be packaged inside ship, then deployed at 400,000-500,000 ft., perhaps as huge umbrella-shaped or balloon structures. The military wants a fiber with flexibility and porosity of textiles plus the 2000°F temp resistance of some metal alloys and ceramics. Fabric Research

Laboratories and Arthur D. Little are doing some of the groundwork in this expanding research.

Production

REDHEAD-ROADRUNNER, new Army target missile system, will use ammonium nitrate solid propellant boosters for initial flight testing. Boosters are now being produced at Rocketdyne.

AIR FORCE PLANT 77 goes under construction this month at Hill Air Force Base, Ogden, Utah. Boeing is slated to begin assembling and checking out Minuteman missiles in this 75-building complex by early 1962.

ELECTRON BEAM WELDING MACHINE is now installed at Rosemount Engineering Co. Accelerated electrons weld exotic materials ranging from 0.003" foil sheet to 0.500" plate.

CARBON ARC IMAGE FURNACE generating 6000°F is being made by Goodyear Tire & Rubber to test experimental rocket liners.

Procurement

WINTER STUDY REPORT was recently "discussed" at a meeting of C^2D^2 officials and industry communications media. It recommends areas for r & d on electronic information and control systems in the 1960-70 period. Air Force's Command and Control Development Div. sponsored study by Mitre Corp.

AIRCRAFT

Design

HAWKER P.1127, British VTOL support fighter, may use reheating at each of its four nozzles in advanced supersonic versions. Common shaft drives the nozzles which can be swivelled from facing directly aft to facing directly forward. Initial versions will be subsonic and designed for attack and support.

NEW CONVAIR 880-M utilizes four slats on leading edge of each wing to achieve shorter landing distances. Two are between the engine pods and two outboard of each outboard pod.

F-27 now incorporates hydraulic power for its nose wheel steering. Motor pump package is manufactured by Kellogg Div., American Brake Shoe Co.

RING-WING VTOL/STOL has been designed and patented by Piasecki. Props are mounted within two circular wings on either side of fuselage. Flaps and vanes inside wing-shroud can be lowered to provide deflected slipstream for vertical lift.

Development

T.S.R. 2, a supersonic tactical strike and reconnaissance aircraft, is now being developed by the British Aircraft Corp. for RAF. It is an "advanced conception" capable of using short and low grade airfields.

LIQUID METHANE AND PROPANE may serve as fuels for the next generation of jets. They can absorb far more heat than current jet fuels. Missile propellant experience is helping solve the engineering problems of keeping the gas in a liquid form in the aircraft.

Production

FIRST CHINOOK (YHC-1B) slated to roll out in January at Vertol's Morton, Pa., plant. Helicopter will be powered by twin T55 turbines. Vertol has ten "in house". Last five will be called simply HC-1B. Model II of the Vertol 107 is meanwhile making its initial flights, with T58-8 engines giving 2300 shp.

BOEING-WICHITA can now bend eight-inch-diam. 0.044 thin-wall aluminum tubing for use in B-52H. This is the first time eight inch tubing has been used in aircraft production.

T-39 SABRELINER production orders now total 94.

DUAL PODS for B-58 fuel and payload are now being produced at Convair-Fort Worth. Lower portion is dropped with its fuel exhausted. Upper portion carries nuclear bomb and is dropped with the bomb.

F-101B "VOODOO" production is slated to end next month.

Procurement

VTOL GUIDELINES are now under study by special Defense Department committee. Its report, expected shortly, will help determine what VTOL types will be further developed. Requirements of each of the services are being jointly reviewed to determine areas of common interest.

The Aerospace M·A·P

This capsule of business developments and trends is part of Aircraft & Missiles' Marketing Assistance Program, a research service to aid companies in the aerospace market.

Stops To Be Pulled In Space Race

When the lid pops off the traditional Eisenhower $40 billion defense budget, spending won't climb, it will soar. The time is not far off. And individual companies in the aerospace industries must be prepared to move swiftly or be left behind.

An Agreeable $3.5 Billion

Neither Presidential candidate has come forward with a crystal-clear statement on how he will perform as Commander in Chief of the Armed Forces. But this much is clear. Both are nearly committed to an almost immediate increase of $3.5 billion.

Senators Johnson and Symington have long taken a stand on the need for this boost. They will play key roles in Kennedy's defense planning—if . . .

Vice President Nixon has allied himself with the Republican rebel Rockefeller. Before they were so amiable the Governor spoke long and hard for the need of an increase in defense spending identical to the Democrats' $3.5 billion. Nixon's yielding in this area is reportedly cause for their makeup.

In recent months, even the present Administration is willing to take credit for budget increases that it resisted over Congressional objections a year ago.

Disarmament — The dove of peace that flapped its wings so hopefully during Camp David and before the Paris Summit has spun in.

Present indications are that the Soviet Union is not serious about disarmament. Or at least we are not willing to take them seriously. In conventional arms, the pace must be maintained if not increased. The rate of technology is such that weapons of the early 60's will soon be obsolete. This means high replacement costs even if the weapons are not expended.

There is also growing realization that we are in a desperate space race. Neither future Commander in Chief seems willing to leave any doubt about who is in charge out there.

On Spot Spending

More money will go into long range research; more will go into on the spot buying. A decreasing percentage of the total budget will be committed on a yearly basis. This is why individual contractors must keep their capabilities constantly in front of DOD and the prime contractors. There is now $8 billion in DOD without contract obligation. Two to three billion will

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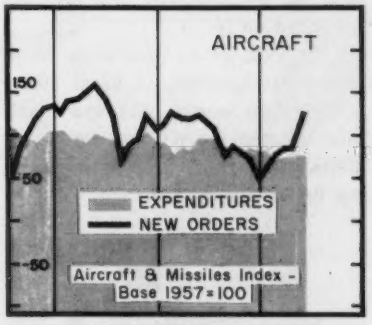
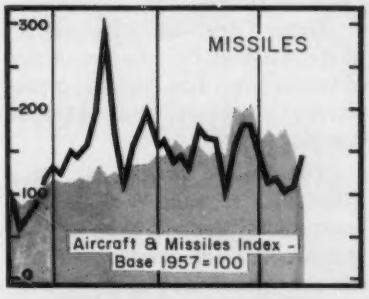
DEFENSE EXPENDITURES AND NEW ORDERS

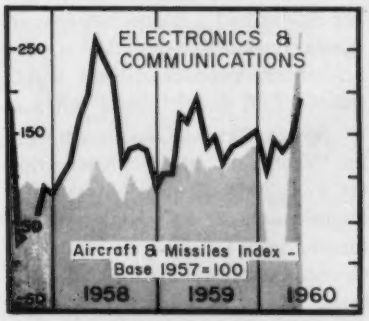
3 Months' Moving Average Index



Aircraft includes air-frames, engines, armament, electronics, and other government furnished equipment. Also included: special tools, test equipment, and ground handling equipment.



Missiles graph includes complete missile systems—armament, launching, guidance, control, boosters, sustainers, propellants, special tools, and ground handling equipment.



Electronics and communications graph is related to the following equipment: radar, electromagnetic equipment, computers, radiation airs, countermeasures, radiac and infrared, meteorological equipment, sonar, transmission or reception units, noise and interference detection devices, test equipment, spares, and related component equipment.

THE CIVIL AIRCRAFT MARKET

AIRCRAFT SHIPMENTS

Month	Units 1960	Units 1959	Value (000,000) 1960	Value (000,000) 1959
January	747	665	$96	$50
February	855	619	113	50
March	867	736	90	34
April	768	745	127	68
May	802	759	131	81
June	694	779	110	65
July	539	630	120	88
August	....	847	....	95
September	....	432	....	76
October	....	739	....	104
November	....	705	....	77
December	....	786	....	112
Year		8,242		$900
7 Mos.	5,272	4,933	$785	$436

PISTON ENGINE SHIPMENTS

Month	Units 1960	Units 1959	Value (000,000) 1960	Value (000,000) 1959
January	1,025	873	$2	$3
February	1,039	954	3	3
March	1,141	921	3	3
April	1,064	947	2	3
May	894	921	2	2
June	772	979	2	3
July	579	844	2	2
August	....	747	....	2
September	....	804	....	2
October	....	1,051	....	4
November	....	1,060	....	4
December	....	1,051	....	4
Year		11,152		$35
7 Mos.	6,514	6,439	$17	$18

The Aerospace MAP

. . . continued

be doled out before the end of the fiscal year.

About $306 million recently went to Navy and Army to strengthen their missile arsenals. Army drew $200 million for Nike-Zeus, Navy $106 million for Polaris. The next big decision will be a contract go ahead on B-70.

So, look for an immediate surge in defense spending in fiscal 1961, $3.5 billion worth. Aerospace will take a large share. By 1965 economic analysts see aerospace spending up nearly 20 per cent.

Business Moves

Avco's Crosley Div. is now called Avco Electronics and Ordnance Div. This will be part of firm's new Defense and Industrial Products Group.

Hupp Corp. expands activities of its Aviation Div. by acquisition of Gemco Inc., Los Angeles, manufacturer of ejection and separation systems.

The Donaldson Co., St. Paul, Minn., has acquired two-thirds interest in Hydrodyne Corp., North Hollywood, Calif. producer of missile and rocket fluid-handling components.

Aerojet-General Corp. now has a controlling interest in Space Electronics Corp., Glendale, Calif. Firm has established a Spacecraft Div. in Azusa responsible for design, development, production and flight-testing of all Aerojet space vehicles.

Sperry Phoenix Co. is entering the "lightplane" market. It is setting up a nationwide distributor-dealer organization for selling its new automatic pilot for a variety of Beech, Cessna, Aero Design, and Piper aircraft.

ITT and McCormick Selph Associates will manufacture and market exploding bridgewire systems for the missile and space fields and for industrial use. Agreement combines ITT electronic and Mc/S/A explosive ordnance know-how.

Avco Corp. has formed a Defense and Industrial Products Group, which will include the firm's Crosley, Lycoming, Nashville, and Research and Advanced Development divisions.

Space Age Industries Inc. was recently established in Los Angeles to specialize in research and production of electro-mechanical transducers and associated instruments for the aviation, missile and automation fields.

Space Technology Laboratories now has a Canoga Park Div. for work in advanced communications systems, counter - countermeasure equipment, infra - red equipment, penetration and reconnaissance systems.

Cessna Aircraft Co. has purchased McCauley Industrial Corp., Dayton, O.

Facilities

Princeton University is operating a new VTOL test facility employing a 760 ft shed and a mechanical arm.

Perkin-Elmer Corp. is building a new plant in Wilton, Conn. for the engineering and advanced research and development groups of its Electro-Optical Div. It is slated to be completed in April.

Calumet & Hecla Inc. begins zirconium and titanium production Jan. 1 at its new 60,000-sq-ft Inkster, Mich. plant.

Douglas Aircraft Co. recently opened an engineering measurement standards laboratory at its Santa Monica Div.

W. L. Gore & Asso. will soon open a $75,000 research, development and manufacturing facility in Newark, Del.

Aeronutronic Div., Ford Motor Co. will build a 115,000 sq ft building in Newport Beach, Calif. for its space technology operations.

Corning Electronic Components will build a new plant at Raleigh, N. C., for production of glass capacitors.

Contracts

Western Electric Co.—$199,-125,000 from the Army for Nike Zeus r & d; $18-million for items to improve capability of Nike Hercules. Douglas Aircraft and General Electric will share in latter work.

Douglas Aircraft — $71.5-millions for further production of Navy A4D-2N "Skyhawk" aircraft.

Chance Vought—$68-million to the Aeronautics Div. for continued production of Navy F8U-2N aircraft.

Lockheed Aircraft—$50.0-million from the Navy for continued production of GV-1 Assault Tanker aircraft to be used by the Marines.

Rocketdyne—$44-million for a 4½ year development and qualification program on NASA's 200,000-lb-thrust J-2 engine for Saturn.

General Electric—$32,500,000 from the Air Material Command to produce the J85-5 afterburning jet engine which will power the T-38 "Talon" trainer.

The Raytheon Co.—Four Army contracts totalling $29,597,535 for continued Hawk production; $10,-566,490 to produce Hawk system components for use in the Military Assistance Program and NATO.

Thiokol Chemical Corp.—$17-million for work on the Air Force's Minuteman first stage engine production facility west of Tremonton, Utah.

The Martin Co. — $10-million for r & d on Pershing.

Grumman Aircraft — $8,376,-034 subcontract from Bendix for production of the Eagle airframe and propulsion system launcher; also for modification of a test bed aircraft carrying Eagle.

Goodyear Aircraft—$2-million to develop advanced manufacturing techniques for Nike Zeus components.

New Books

THE AERODYNAMICS OF POWERED FLIGHT. By Robert C. Carroll. Wiley, 1960. 275 pp., $8.50. Guided by his teaching experience, the author of this work has endeavored to approach the subject through a more logical avenue than the customary historical one. He has intended this book as an introduction to the areodynamics of powered flight at the undergraduate level. His fundamental approach to lift uses the rocket as a propulsion system because it allows the greatest simplicity of analysis. Chapters are devoted to the following topics: mechanics of flight, introduction to aerodynamics; pressure distribution and lift; lift analysis; boundary-layer effects; compressibility in subsonic flow; lift and drag variations with boundary-layer effects; shockwave analysis; wave combinations; thin airfoil theory; sweepback and transonic effects; propeller analysis; airplane performance; maneuvering flight; stability and test aids.

THE TALE OF THE COMET. By Derek D. Dempster. McKay, 1960. 218 pp., $4.00. A great epic of modern commercial aviation written by a fighter pilot in a lively and sensitive style. The book covers the full history of the Comet's development, its construction, success, the two disastrous accidents, the scientific sleuthing which traced the causes, and the lessons learned which have since contributed to the safety of air travel.

DEVELOPMENT OF ULTRA-HIGH STRENGTH, TEMPER-RESISTANT STEELS DESIGNED FOR IMPROVEMENT OF FATIGUE PROPERTIES THROUGH RELIEF OF RESIDUAL STRESS. H. B. Nudelman and J. P. Sheehan, Armour Research Foundation of Illinois Institute of Technology for Wright Air Development Center, U. S. Air Force. June 1959. 32 pages. High-strength (300,000 psi), medium-carbon (0.30 to 0.55 per cent) steels which can be tempered at 1200 to 1300F to hardness levels approaching Rc 62 were developed. Order PB 151971 from OTS, Dept. of Commerce, Washington 25, D. C. Price: $1.00.

CLASSIFICATION OF ELECTRON TUBES. By J. Haantjes and H. Carter. Macmillan, 1960. 100 pp., $3.50. This book is intended for readers interested in acquiring the basic phenomena related to electron tubes. It explains in simple terms how they operate and how they are classified by function. Lucid color illustrations and cutaways are used profusely to explain the behaviour of electrons and to describe the structure of tubes. Included are also a glossary of "odes" and "trons," as well as a chart showing the generic classification of the principal types of electron tubes.

AEROSPACE FACTS AND FIGURES. Edited by Ben S. Lee. American Aviation Publications, 1960. 143 pp., $2.00. This is the official, annual publication of the Aerospace Industries Association of America. It presents the vital statistics of aerospace activity from the following aspects: production and facilities, military aviation, guided missiles, space program, research and development, manpower, finance, general aviation, helicopters, airlines and transportation, aviation export and foreign aviation.

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Tougher... Lighter... Smaller

handles more air...with minimum pressure drop

– and gives you all these other advantages –

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Handles any job in your shop using ¾" to ⅛" connections— from the air line to the air tool.

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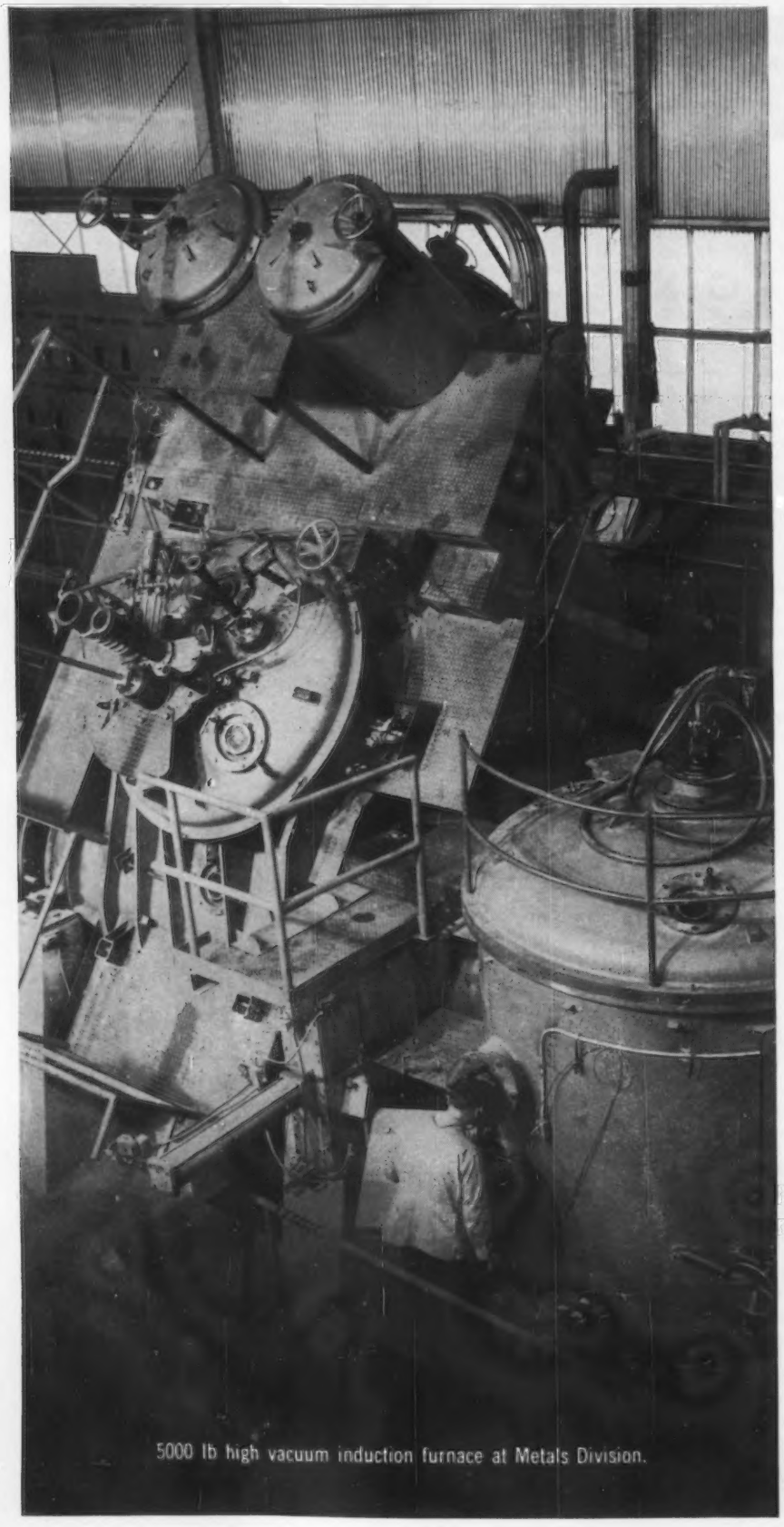

5000 lb high vacuum induction furnace at Metals Division.

Are you after highest alloy properties in heat-after-heat?

100 per cent composition control assured by vacuum induction melting

Highly reactive elements enhance high-temperature alloy properties. Today, only one production metal refining process can effectively control the action of these elements, and—heat-after-heat—meet the most exacting alloy specifications.

The process is vacuum induction melting, and the only specialist in this process is the Metals Division, Kelsey-Hayes Company.

In a specially designed plant which contains seven vacuum induction furnaces with a monthly capacity of 1 million lb, the Metals Division produces over 50 alloys for critical high-temperature, high-stress applications such as aircraft gas turbine buckets and wheels, missile and nuclear components. Alloys like Udimet 500 and 700 were developed by Metals Division. The Division is the leading producer of vacuum induction melted Waspaloy, M-252, and other alloys. Kelsey-Hayes Company, Detroit 32, Mich.

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Automotive, Aviation and Agricultural Parts
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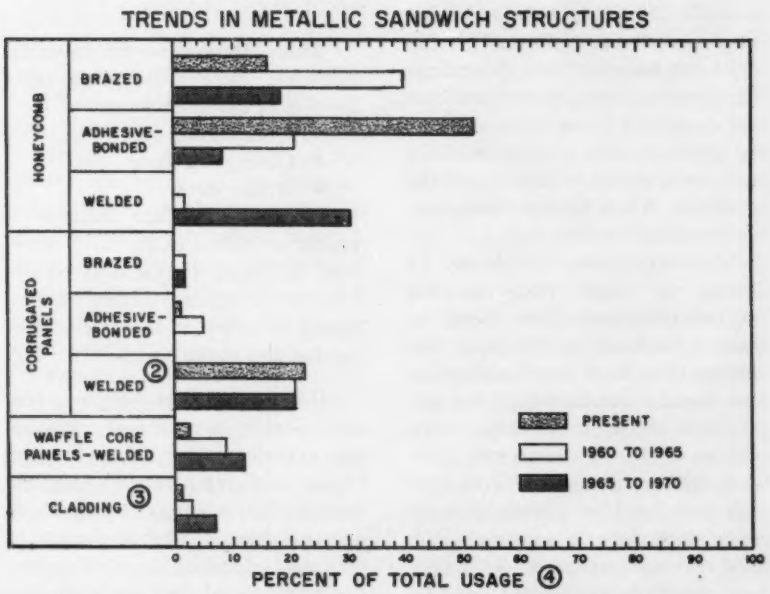
18 PLANTS: Detroit and Jackson, Michigan; Los Angeles; Philadelphia and McKeesport, Pennsylvania; Springfield, Ohio; New Hartford and Utica, New York; Davenport, Iowa; Windsor, Ontario, Canada.

AN AIRCRAFT & MISSILES SPECIAL STAFF REPORT

Sandwich Structures . . . The Status and The Outlook

Big market just ahead for brazed stainless honeycomb; Refractory metals, ceramics, welded stainless figure in future; Costs must be reduced to entice commercial use



Study limited to airborne vehicles with speeds of Mach. 9 or higher.

Includes "open-faced" material structure (corrugation-welded to one face sheet) for skin panels, floor construction, missile bodies.

Includes coating or cladding of exterior surfaces regardless of the type of structure, e. g., conventional, honeycomb, corrugated or waffle core.

Total usage is estimated on a weight basis. Requirements for individual types of material structure are expressed as percents of the total estimated weight.

There is a bright future ahead for sandwich structures. Both all metal, and ceramic-metal types can plug big gaps in aerospace materials needs. Rebirth of the B-70, increased attention on Dyna Soar, and the need for long-life, uncooled rocket nozzles are providing new market impetus.

The commercial application of high-temperature sandwich is small. The potential is large. Costs ($150-$200/ft^2 at present) are still too high. Trends show that by 1965 price will drop to $50-$75/ft^2. This is a price that the commercial market would probably tolerate.

Hi Temp—Hi Density—Metals commonly used for high temperature applications have high densities. Many designers see the use of integrally stiffened structures and other conventional weight-cutting techniques as inadequate. Sandwich

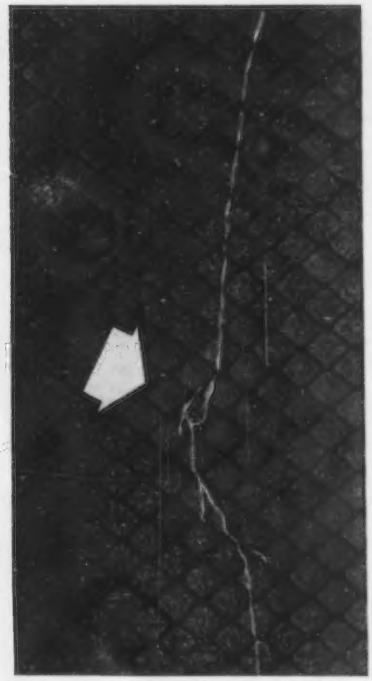
. . . *continued next page*

Air Force projects represent biggest market; WADD studying sandwich for space vehicle

construction is a good means of circumventing high specific gravities.

Intelligent design with sandwich structures gives much lighter configurations than the conventional construction. It permits use of thin face sheets stabilized with low density media to give maximum yield strength of the materials. The market for this kind of construction will increase since a growing percentage of both aircraft and missile frame are becoming critical.

High strength-to-weight ratio is not the only advantage of all-metal sandwich. Thermal resistance is excellent. It can protect critical substructures and fuel areas. It provides a smooth skin surface.



INSPECTION is big factor in honeycomb structures. The B-70 panels will probably be 100 per cent X-ray inspected initially. But then will be used mostly to backup less expensive methods like Magnaflux Bond Check. This technique has not been refined to detect stress cracks. Crack shown escaped ultrasonic test.

Ceramic Sandwich — Growing use of metal and fiberglass sandwich has awakened an interest in ceramic structures. Boeing, in its Dyna Soar studies, has given ceramics particular attention.

Major reason for interest is, of course, high rigidity and strength-to-weight ratio. Second consideration is the possibility of sandwich use in antenna windows. Some sandwich structures have better broadband radar transmission than single wall windows.

The variety of ways ceramic sandwich can be used in high temperature thermal insulation is a matter of extreme interest.

One type ceramic sandwich studied by Boeing is made from a variety of dense high purity refractory oxides in conventional honeycomb core, and sine wave corrugated core sandwich configuration. They use unfired pure oxides such as Al_2O_3, ZrO_2, MgO-Al_2O_3, or carbides in a plasticized form. This material can be rolled into thin sheets like paper and then formed into core and cemented to skins to produce the sandwich. The cement is of the same composition as the rest of the sandwich. When fired a homogeneous structure results.

Another sandwich evaluated by Boeing is made from ceramic bonded refractory fiber paper or board. Sandwich of this type has very good thermal shock resistance, low thermal conductivity, and appreciable impact resistance in comparison to the dense ceramic sandwich. Filling the sandwich core cells with powdered or fibrous ceramic material produces a sandwich with good thermal insulation. Such fiber base materials are limited only by the softening temperatures of the ceramic fibers available to date.

Boeing also looks on the metal-ceramic combination as feasible in sandwich consideration (see illustration). This kind of structure would be good for the exterior of hypersonic vehicles. Core would be filled with a fibrous or powder filler to improve insulation. The core might even be evacuated to serve as vacuum insulation. Limitation of this type sandwich is the requirement that it be used in a way that corrugations are parallel to hot-face isotherms.

Several materials suppliers are known to have produced sintered aluminas with moduli of rupture approaching 100,000 psi. This will enhance the potential of ceramics. Lack of ductility is still a big bugaboo.

Avco's Ceramic Mosaic—Avco Corp. has used a ceramic filled honeycomb core in rocket nozzle tests. The core material is at 90 deg to the nozzle face. Ceramic material that fills each cell takes the shape of a pencil. Pencil cross-section is kept small to avoid critical gradients which would produce a rupture.

Basic Designs — In all-metal sandwich, three basic panel types are getting the most attention:

- Honeycomb core
- Corrugated core
- Waffle core

In each, the face material is welded or brazed to the core. However, the main emphasis is on developing a welded, rather than a brazed structure, in the case of corrugated and waffle cores.

Honeycomb Core—Brazing predominates as a means of construction in honeycomb core sandwiches. Operational temperature with the brazed panel is apt to be only about one half the potential of the parent materials. Some of the more sophisticated core and face materials lose optimum properties when subjected to the heat-treating braze cycle. The braze cycle is also time-consuming and the resulting structure is expensive. Repair is difficult and original strength cannot be achieved in repaired areas. An all-welded

panel is therefore much sought.

Honeycomb core has extraordinary strength-to-weight ratio, excellent stiffness, good thermal and acoustical properties, excellent fatigue resistance, and gives a smooth areodynamic surface. It can tolerate biaxial loadings, and it is easy to vary honeycomb cross sections. Advantages of this core are high.

Corrugated Core — When V-shaped core sections are faced, a corrugated sandwich results. A single or double V-type core can be used. Resistance welding is used most widely in fabricating this kind of structure.

Corrugated sandwich has directional load characteristics. It can take more load in a longitudinal (direction of the corrugation) than in a transverse direction. In the longitudinal direction the sandwich is quite rigid from the ribbed support of the core. In the tranverse direction the sandwich is not nearly as stiff or rigid. The directional characteristic can be either an advantage or disadvantage, depending on how the structure is used.

Emphasis on the development of corrugated panels comes from potential superiority of this structure over the honeycomb core sandwich in cost and in the service temperatures. The basic design is relatively simple.

The maximum service temperature is limited only by the properties of the materials themselves. Strength of the bonding element does not enter the picture. This contributes to a great growth potential for corrugated sandwich.

Tapering of corrugated sections is not possible at present. This is a serious design limitation. Some designers are reluctant to use this construction near fuel areas because a leak could spread fuel to normally safe areas. In extreme buffeting, corrugated sandwich does not hold up as well as honeycomb. Thermal insulation properties also seem inferior to those of honeycomb core.

Waffle Core—The waffle sandwich consists of deep-drawn core with a raised and depressed waffle pattern joined to upper and lower face sheets. With the offset waffle pattern, electrodes can be inserted for resistance welding of attachments. The configuration permits isotropic structural properties.

Only limited research and development has been extended to waffle-core sandwich. Problems have been encountered in forming the waffle core to maintain perpendicular walls. Also, difficulty has been experienced with the quality and location of the spotweld and in avoiding undue stress concentrations in the weld attachments. A coin-sized spotweld had been used in the bottom of the waffle depression to broaden the area of attachment. The resulting pattern of spotwelds has tended to produce a slight waviness in the exterior skin. This is undesirable from the standpoint of aerodynamic smoothness.

Application Trends—There is a definite place for several kinds of sandwich in aerospace vehicles over the next decade. Most designers agree that no one structural concept offers a solution to all problems.

In the short haul, next five years, brazed stainless steel honeycomb will account for largest sales. But, welded honeycomb, and welded corrugated structures will move up in the later part of the decade.

The B-70 is an important factor in shaping the market. North American designers are not banking too heavily on welded honeycomb. This reflects that some of the uncertainties in design and production have no immediate prospects of being worked out.

Air Force projects will represent the greater part of the market. NASA and Navy trail. In aircraft, Navy's BuAer sees no large scale use of all metallic sandwich.

Aeronutronic Div. of Ford Motor Co. is engaged in an 18 month guideline study of structures for space vehicles. Sandwich structures figure heavily in this work. WADD is monitoring the contract.

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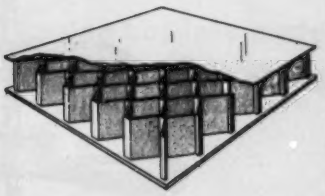
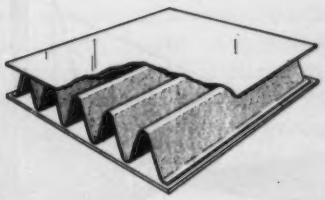
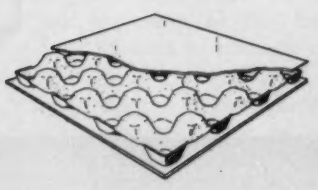
THREE BASIC CORES FOR SANDWICH PANELS



HONEYCOMB CORE

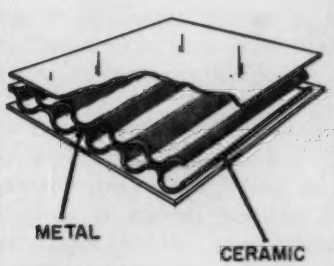


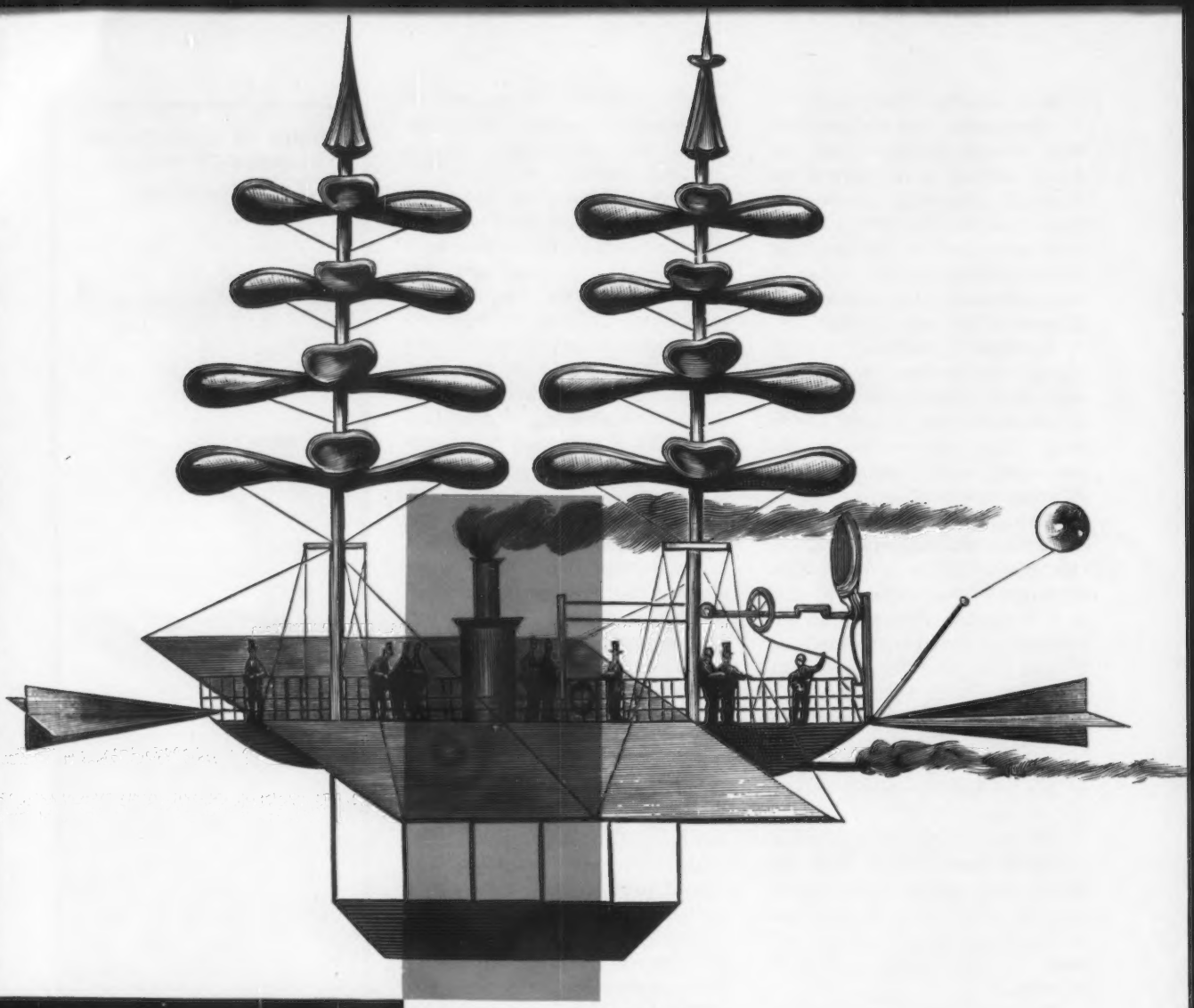
CORRUGATED CORE



WAFFLE CORE

HALF METAL, HALF CERAMIC SANDWICH





The basic principle of the helicopter was first advanced in 1863 by Gabriel De La Landelle of France. Rising steam was expected to turn the air screws and lift the craft upward. For this illustration, Brussel-Smith has followed earlier renderings of the "Steam Airliner" to create this intricate wood engraving.

IMAGINATION IN SPACE

Since Creation, man has looked out on space. At first, unknowing and incurious; then with the beginnings of understanding; now free and able to explore. Yet to move in space calls for wholly new concepts of energy.

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GSE For The Minuteman

From plant to silo, Boeing has integrated ground support equipment into weapon system design

By Frank Verginia, Chief
System Design Section Minuteman
Boeing Airplane Co.

The need for Minuteman to remain on constant alert for years, makes a rigorous method of system design necessary. This system design method entails careful technical consideration of equipment, personnel, supporting data and facilities to achieve the most effective weapon system for the least cost in the shortest time.

The trend to include equipment used in the immediate launch or takeoff as a part of the weapon system has been carried even further in Minuteman. The assembly and support facilities located considerable distance from the deployment areas are considered an integral part of this weapon system.

GSE Reliability Factors—Reason, of course, is to make sure the support activities insure operational effectiveness of the missile. This requirement has placed additional emphasis on the reliability of the ground support equipment (GSE). Reliability improvement factors as compared to present systems are: Electronics GSE—15 to 1; Electrical Power Equipment — 5 to 1; Mechanical GSE — 1.5 to 1. To achieve this upgrading requires a well - disciplined approach toward the design of each component.

The General Operational Requirements for the Minuteman weapon system are broken down into functions. Each of the functions is further broken down into tasks required to accomplish the function. The sequence of tasks outlined include those for maintenance as well as operation of the weapon system.

Role of Designer in GSE—The weapon system designer plays a vital role in GSE. He must determine the functional involvement of the equipment in system operation, he must determine the maintenance concept and its impact upon equipment requirements. He will develop system and equipment design criteria with which he will be able to evaluate the trade studies required to arrive at the optimum GSE configuration. The net result is a ground support system which is based on technical, logistic personnel, facility and operating considerations as well as the functional requirements involving weapon system equipment. The results are expressed in the form Time Line analysis to estimate the number of people and amount of equipment required to meet the operational objectives. One of the major advantages of these surveys is that "trades" are made before hardware design costs are incurred.

Only after all this is accomplished does the preliminary design engineer enter the program to establish detail design for the various components. By using the functional flow model and "dropping out" all the functions of a particular subsystem, the engineer is better able to understand quickly all of the factors to be considered in the system and component design.

Transportation of Minuteman—An example in Minuteman is the transportation system. The large dispersal of missiles increases the importance of the transportation equipment, especially under the op-

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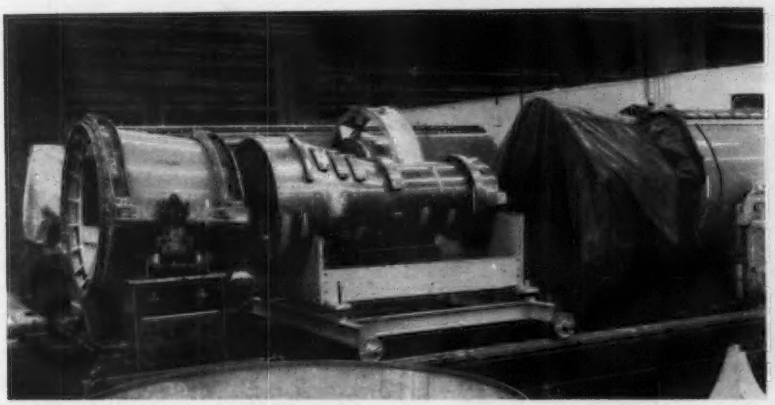

JOINING DOLLY FOR MINUTEMAN ICBM nose section maintains hardware at matching height to engine sections. Each major subcontractor uses same type dolly, this speeds operations at final assembly.

Maintenance concept of "remove and replace" makes transport equipment of prime import

erational maintenance concept which is to "remove and replace" rather than "overhaul on-site."

Excluding the long distance carrier, the transportation system consists of engine harnesses, engine transporters, inplant transporters and handling dollies, and the transporter-erector. Of these, the transporter-erector provides a clear example of how hardware evolves from the functional flow model.

Under the hardened and dispersed concept, the missiles are transported from the support area to the silo launcher. The tasks involved are (1) transport the missile and (2) emplace it in the silo. An additional requirement is that the environment be controlled during the missile's movement. A study indicated that road movement would be best.

Thorough understanding of all the requirements enabled Boeing to break down the work package in a manner that would allow for contracting each portion of the job to the organization most qualified to do the detailed design and construction of the equipment. In this case, General Motors was selected for the tractor and trailer undercarriage; Cessna for the van, and Bendix is charged with developing the emplacement system.

The system design concept insures compatibility between various components. For example, spring rates in the carrier equipment are designed to match those of the handling dollies' suspension systems, limiting the transmission of road shock

UNIVERSAL HANDLING HARNESS (foreground) is designed to accommodate any of Minuteman's three stages. Joining dollies are rolled onto trailer. First stage is shown at Edwards AFB.

ALL THREE STAGES of Minuteman are mounted on large in-plant transporter. Each stage is still mounted on same rail-dolly in which it was assembled. Rails are at constant height above ground in entire operation.

Hard Site GSE — First operational launch complex, consisting of three missile squadrons, will be deployed in a large area near Malmstrom AFB, Great Falls, Montana. Cost of constructing each squadron launch complex, which consists of underground launch silos and control centers, is estimated at $20 million. Construction will begin in January, 1961, and be completed in from 15 to 18 months. The Corps of Engineers will direct construction and equipment installation and checkout will be accomplished by Boeing.

Using the systems design approach outlined previously, operational facilities for the hardened and dispersed concept were established.

The operational launch site is to be unmanned, and each silo will house a single weapon with its launch equipment.

Basic elements are the missile silo, equipment room, hardened enclosure and associated surface facilities. The surface facilities include shelter for non-hardened equipment, erection and vehicle support pad, approach road and security fencing.

Located at some distance away is the launch control center, an underground structure capable of with-

ENVIRONMENT FOR MINUTEMAN

LAUNCHER & EQUIPMENT ROOM:

Equipment must maintain:

Temperature	70° F ± 10° F
Relative Humidity	60 per cent max

Operating conditions are:

Ambient Air Temperature	95° F, dry bulb and 70° F wet bulb in summer to minus 40° F in winter.
Altitude	3,000 to 6,000 ft MSL
Cooling Load	54,000 Btu/hr at maximum ambient temperature conditions.
Heating Load	At minimum ambient temperature.
Preheat	12 kw maximum
Reheat	4.8 kw maximum
Room Heat	1.5 kw maximum
Volume of Supply Air	1,340 cfm
Outside Air	100 cfm

LAUNCH CONTROL CENTER:

System must maintain:

Temperature	75° F ± 2° F
Relative Humidity	45 per cent nominal

Operating conditions are:

Ambient Air Temperature	95° F, dry bulb and 70° F, wet bulb in summer to minus 40° F in winter.
Altitude	3,000 to 6,000 ft MSL
Cooling Load	100,000 Btu/hr at maximum ambient temperature conditions.
Heating Load	At minimum ambient temperature conditions.
Reheat	12 kw maximum
Room Heat	3 kw
Volume of Supply Air	2,800 cfm
Outside Air	140 cfm

ELECTRONIC EQUIPMENT

Supply Air Temperature	55° F ± 2° F
Supply Air Relative Humidity	60 per cent maximum
Temperature Rise Through Cabinets	12° F
Pressure Drop Through Cabinets	1½ in. W. G.

standing very severe over pressures. In addition to the launch control equipment, the center will contain batteries for emergency power and provision for the crew to live there, if necessary, for any extended period of time.

The Minuteman launch control system is composed of the control, monitor, communications, electrical power and security systems. Here again, the system design approach resulted in a close coordination of all equipment requirements, simplifying the total complex.

Analysis of system operational requirements revealed the need for human control of the weapon system. An operator in the launch control center is provided with a unit referred to as the Comman Control Console (CCC) to provide this capability.

The command control console displays the status of all the launch silos. Since the launch sites are unmanned, it is necessary to remotely monitor and control the operation

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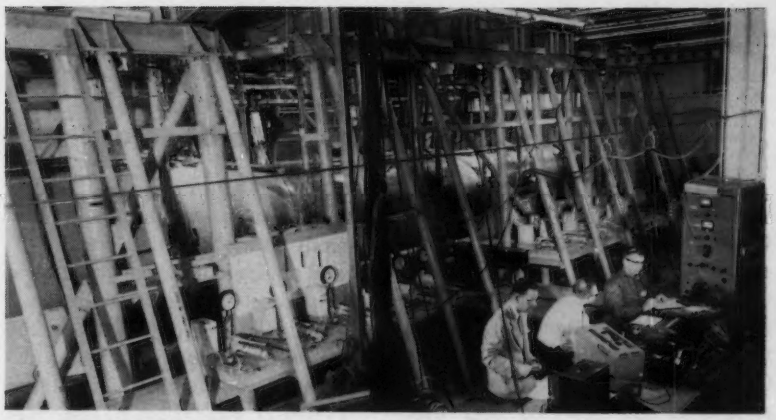
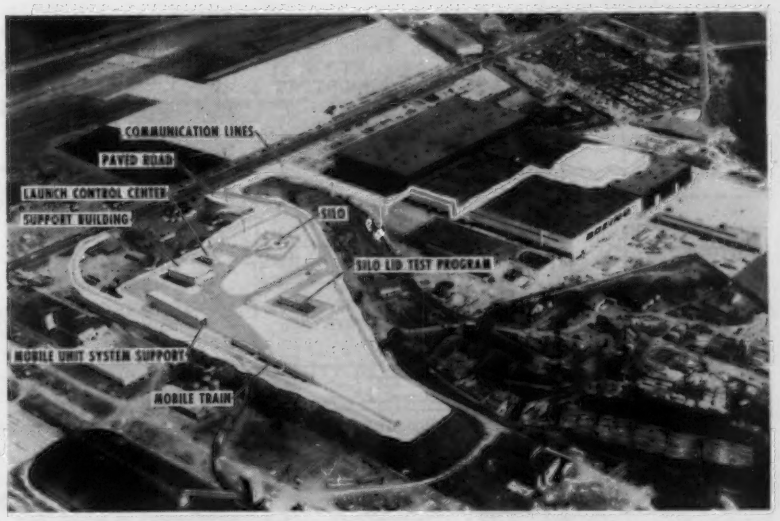


DYNAMIC TESTING of assembled Minuteman requires special GSE. Stresses imposed simulate actual conditions of launch and burnout. Transportation vibrations can also be simulated.

COMMAND CONTROL console for Minuteman is located some distance away from silos in underground center. The console reports 6 basic status conditions of all missiles in a complex.

BLOCK HOUSE for recently completed $7 million flight test facility at Cape Canaveral has 29 ft height, 55 ft diam. Interior has 2 levels. Operational control center at Malmstrom will be underground.



SIMULATED LAUNCH COMPLEX will be constructed at Boeing-Seattle. Objective at this ground support site will be to confirm overall integrated systems design.

Electronic packaging sets new trends, "Floating" connectors are free of stress

of the unmanned GSE. This function is fulfilled by a device called the sequencer and monitor. It accepts commands from the terminal equipment in the launch site and takes the proper action to execute these commands. Six principal status conditions are reported and displayed on the CCC: Strategic Alert, Launch-in-Progress, Missile Away, Test-in-Progress, Calibrate-in-Progress, and No-Go. Also, an alarm signal is sent to the launch control center if an equipment malfunction has occurred that will not prevent firing the missile but does require attention at the launch site.

Environmental System—Of special import in the launch complex are the environmental control systems. Departure from a relatively narrow range of air temperatures and relative humidity can result in inoperable status of some electronics.

BMD thinking has been to award a limited engineering and development contract for environmental controls. Successful completion of such a contract would probably lead directly to a production contract to install equipment at the Malmstrom site. Decision is expected shortly.

Reliability requirements for the environmental control systems establish a mean time between failure (MTBF) of 14,000 hr. MTBF may be defined as the number of total hours of running time, without maintenance, for a system, or a group of systems, divided by the total number of failures occurring during that time.

It is believed that a system reliability of 14,000 hr MTFB can be attained, using presently available commercial components. However, considerable care must be used in selecting these components and some equipment may require a limited amount of upgrading.

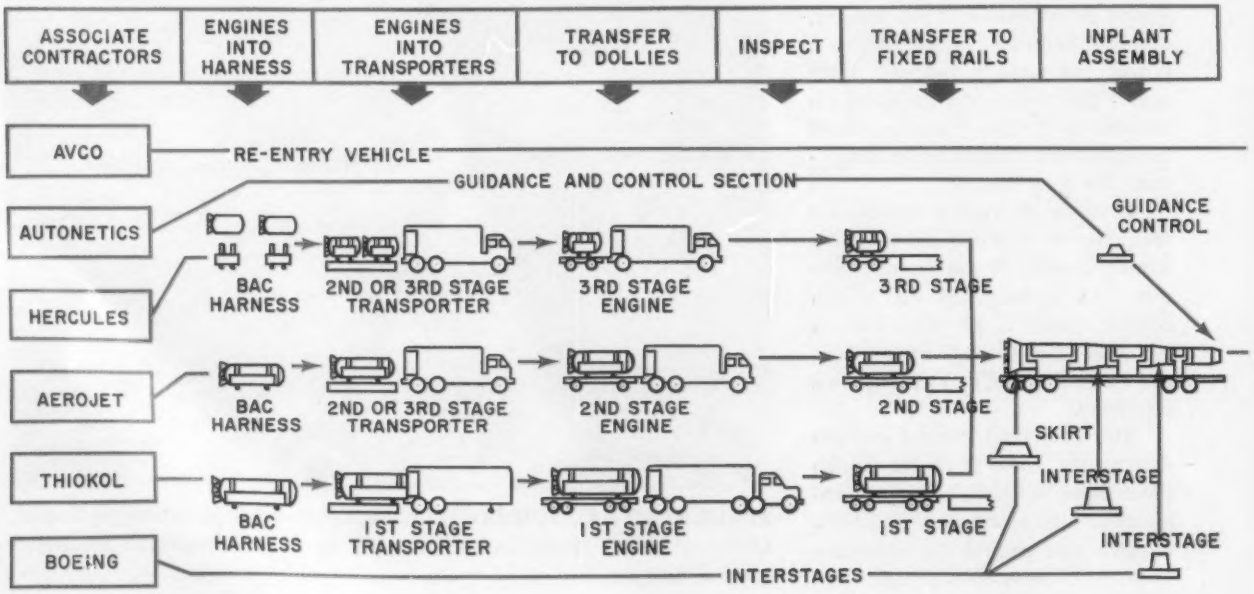
Security Network — Security at the launch silo is provided by fencing and sensors placed about the installation. The security sensors are monitored and a "Security-Violated" signal is reported if okay. Security of the launch control center, however, is maintained largely by personnel placed at points of entry.

Little information can be released concerning the sensitive command and support information networks. But, the systems will provide simultaneously an almost zero possibility of inadvertent launch while having the ability to launch reliably even after enemy attack.

The equipment normally operates from AC power supplied from commercial sources which is converted to DC transformer-rectifier units. Batteries, located in the underground installation, which are connected to the same switching and voltage-regulatoing equipment, can provide emergency power for a number of hours.

Electronic Packaging — Electronic equipment for the launch control system is packaged in standard cabinets designed to accommodate replaceable drawers. The drawers contain printed circuit cards on which the electronic components are mounted. The cards are keyed so they cannot be inserted in the wrong place. Connectors are "floating" so that no mechanical stress is placed on the electrical connections when the drawer is installed. The drawers are keyed too.

The cabinet contains a wiring panel board on which all of the in-



terconnecting wiring for the drawers and the interconnections into and out of the cabinet are placed. This complete wiring panel is removable for ease of modification in the field. Plenum chambers are provided on each side of the cabinet to direct cooling air horizontally between the circuit cards to cool the electronic components, thus greatly increasing the reliable operating life.

Mobility — Mobile deployment of Minuteman missiles is predicted on the use of existing railroad networks. The system uses the same missile as in the hardened and dispersed system. In addition, identical ground support equipment is used where possible.

The mobile trains units are designed to be self sufficient. Each train will consist of a number of launch cars, a command car, power car, personnel cars, fuel and water cars.

Four basic systems are included in the electronic support equipment: checkout and firing, communications power and security.

Major elements of the checkout and firing system are the sequencer and monitor and the operations control console. For communications, the alert and execution system handles Strategic Alert and Launch commands. The support communications system handles operational, administrative and maintenance messages. The trail will contain its own power generating equipment and a backup system for short-time use.

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TRANSPORTER - ERECTOR is major element in transportation and emplacement of Minuteman. Prime mover is 4-axle tractor with V-12 engine. Enclosure has strict environmental controls.

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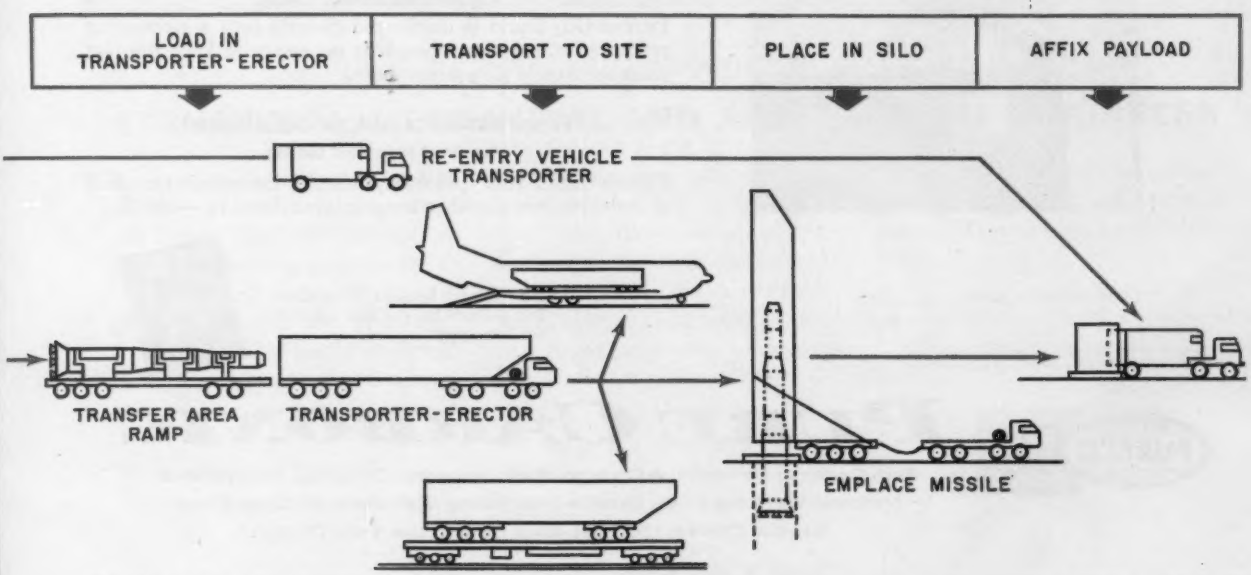

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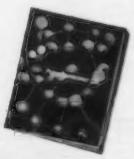

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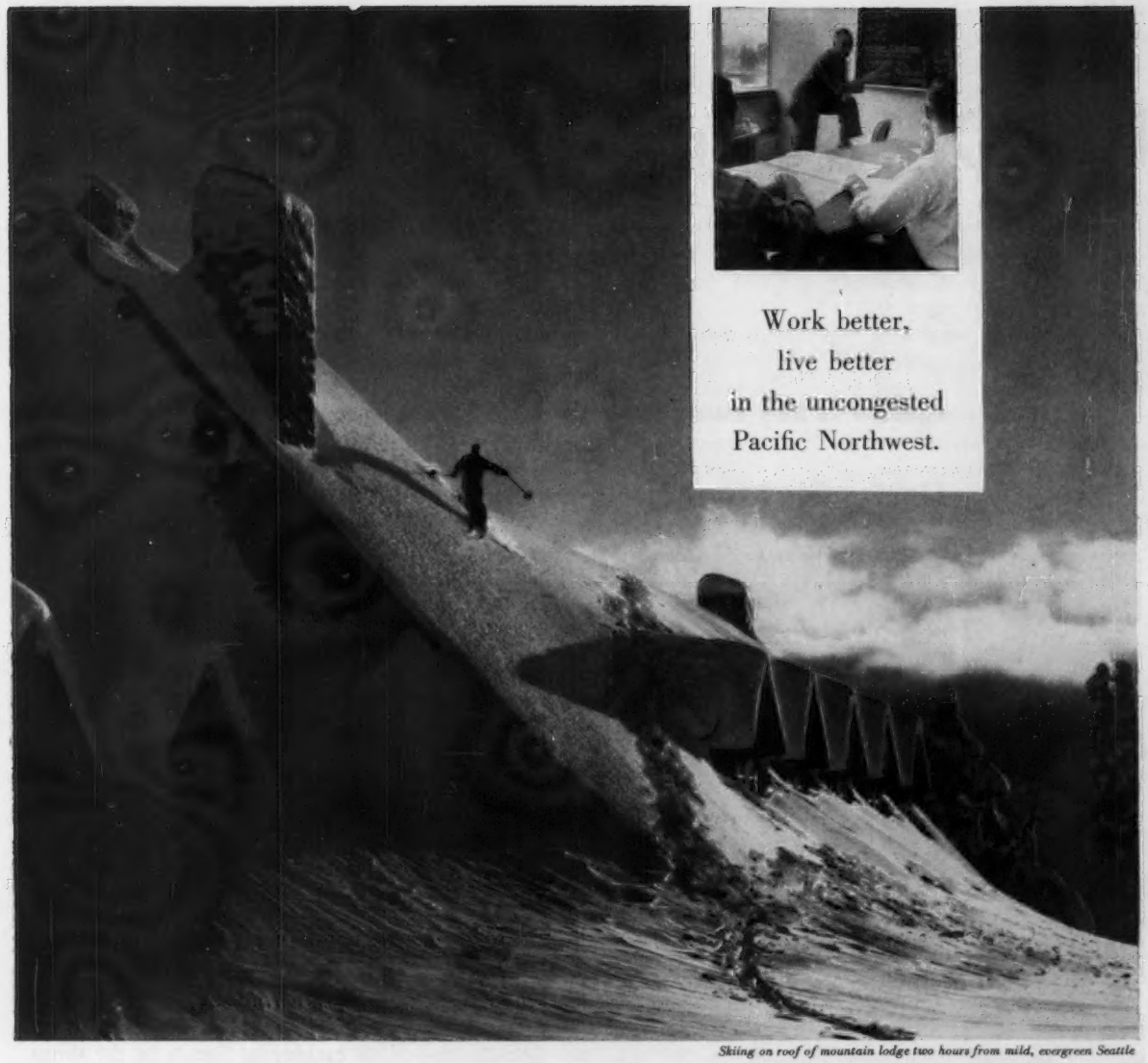

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TRANSPORT DIVISION **BOEING**

How X-15's Engine Is Made Safe

Igniter is key component in XLR-99 design;

Lights off in two stages, then burns continuously,

Prevents accumulation of unburned propellants

By John P. Kushnerick

A question mark punctuates every design move in the XLR-99 rocket engine. "Is it safe enough?" Manned safety is the requirement eterne for X-15's new engine.

Explosion is the greatest fear in any liquid-rocket power plant. It is likely to occur when unburned propellants collect in the thrust chamber. Designers calculated that a dangerous amount of propellants could accumulate in 1/200 sec with pumps up to full speed if XLR-99 used a conventional design approach.

Find A Better Way — "Attempting to sense and correct in this amount of time seemed ridiculous. We had to find a better way to make the engine safe." (Bob Seaman, Project Engineer.)

Staging the ignition proved to be that better way. Though it is not readily apparent, the XLR-99 is three engines in one: two small igniter rockets, and the overall powerplant.

Initial ignition occurs in the first stage igniter. A small amount of propellant is ignited by electric spark from one or all of three spark plugs. The liquid oxygen is gasified in a heat exchanger before it enters this igniter. If ignition does not occur the vapors are blown harmlessly through the second stage igniter and out the main thrust chamber exhaust. There is no buildup, or accumulation of oxidizer.

If ignition is successful in the first stage igniter, a signal from the control box allows the propellant combination to enter the second stage igniter. Light off here is from the already burning first stage. If propellant mixture is improper, excess fluids are vaporized from the heat of the first stage and blown out the exhaust. The chance of dangerous accumulation of propellants is small.

Safety In Main Chamber — Flow of propellant combination to main thrust chamber is triggered by "all's well" signal from second stage igniter. This igniter blows flame into the thrust chamber through the center port of a hemispherical injector dome. Main propellant flow is directly into this flame. Ignition or vaporization occurs. There is still very little chance of buildup of liquids in the thrust chamber.

Thus, explosion is largely engineered out at XLR-99. The design approach makes millisecond sensing of unfavorable propellant combinations less critical.

Thrust Range — Running at maximum engine pressure, XLR-99 produces 50,000 lb of thrust at sea level. This is throttable by the pilot across the range back to a minimum of 25,000 lb thrust.

Egine can also be run for short periods at 400 lb thrust if only turbopump and igniters are allowed to operate. After about 30 to 60 sec, overheating of injector fact chamber occurs. This low thrust range is seen as a possible operating mode in follow on engines. Out-

put can be increased to 1000 lb thrust by a sequencing adjustment of engine pressure.

Durable Engine—Among rocket engines, XLR-99 is extremely durable. It has capability to be stopped and restarted 5 times in each X-15 flight. This limit is set by the supply of purging gas in the aircraft. Planned operating time before overhaul is one hour or 100 airstarts.

At Reaction Motor's Lake Denmark test facility one engine has been through 200 start cycles. Maximum continuous operating time has been 5 min at 50,000 lb thrust, 7 min at low thrust. Propellant supply at the test site is the limiting factor.

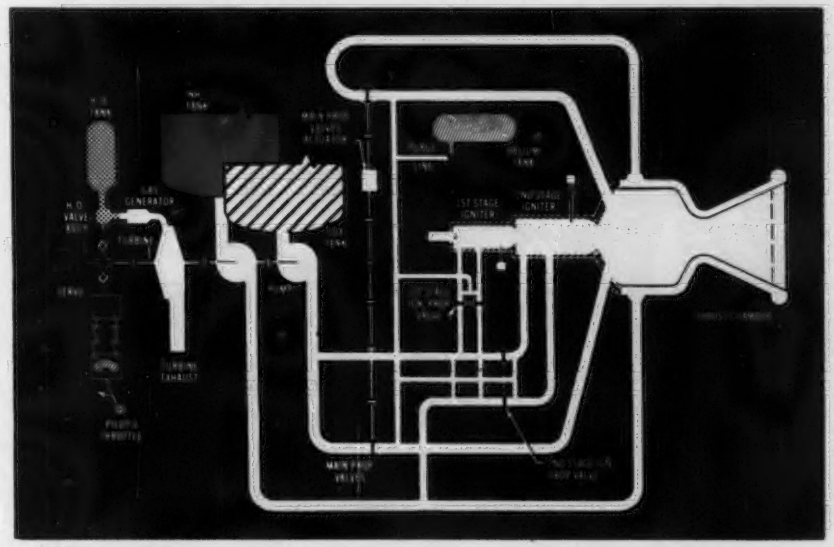
XLR-99 In Dyna Soar—Next logical step for the XLR-99 is Dyna Soar. Air Force now has an engine designed around manned safety, they will probably use it. Reaction Motors has already made overtures to Boeing to incorporate the engine in the first Dyna Soar glider test vehicles that will be dropped from B-52.

As the program stands, modified Titan will boost unpowered glider in sub-orbital second-phase tests. The ultimate Dyna Soar vehicle will probably be Saturn boosted and contain its own powerplant.

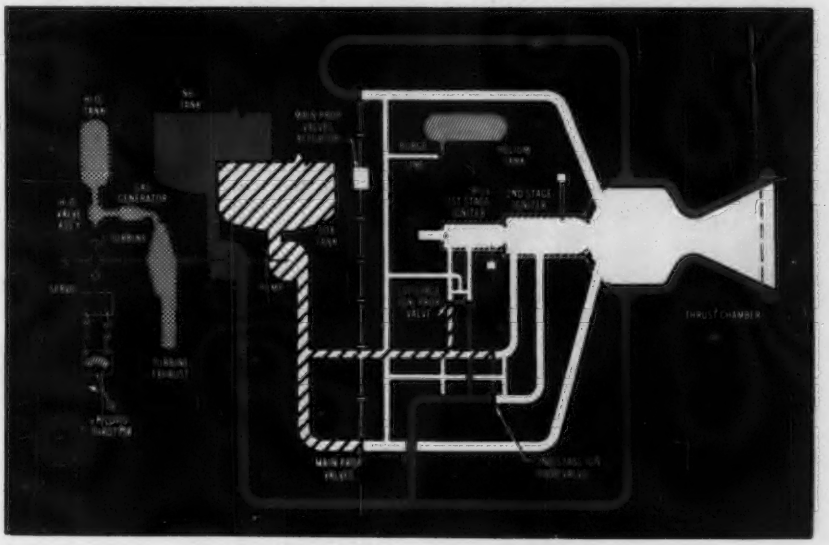
Reaction believes XLR-99 has has growth potential to 100,000 lb thrust with a more dense propellant combination. Hydrazine and N_2O_4 would give this much push. Engineering changes that would be required are:

(1) Increase thrust chamber area to maintain 600 psi chamber pressure.
(2) Redesign some of the seals to make them compatible with new propellant combination.
(3) Simplify igniter system since no spark is needed to initate combustion of this hypergolic combination.

ENGINE IS STARTED by moving pilot's throttle lever. Electrical servo then actuates metering valve that permits concentrated H_2O_2 to flow to gas generator at 50 to 120°F. H_2O_2 passes over catalyst, decomposes to steam and free oxygen generating 1360°F temperature. Turbine speed is between 10,000 and 12,500 rpm.



HOT GASES DRIVE turbine which is connected to vane-type pumps for liquid oxygen and liquid nitrogen. Propellant flow is started and travels through respective plumbing to propellant valves. Liquid ammonia passes through engine chamber walls before reaching main propellant valve.



Concentrated Hydrogen Peroxide
Liquid Ammonia
Liquid Oxygen
Helium

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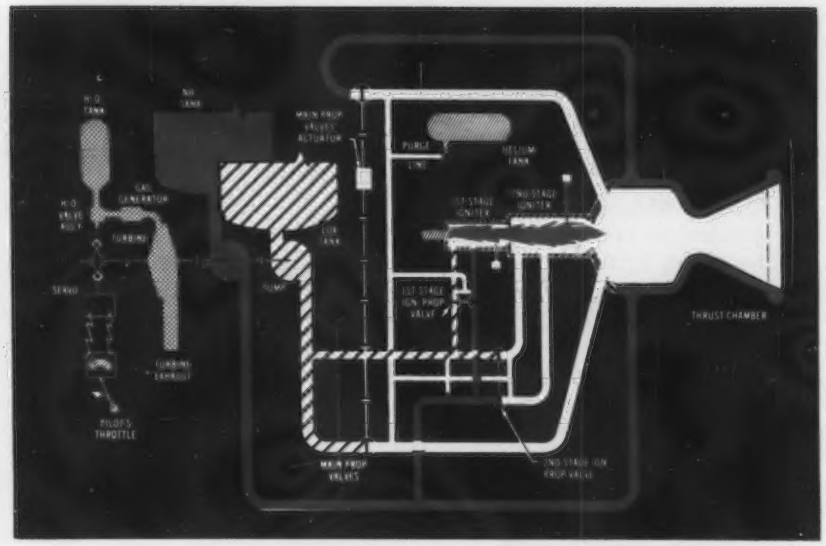
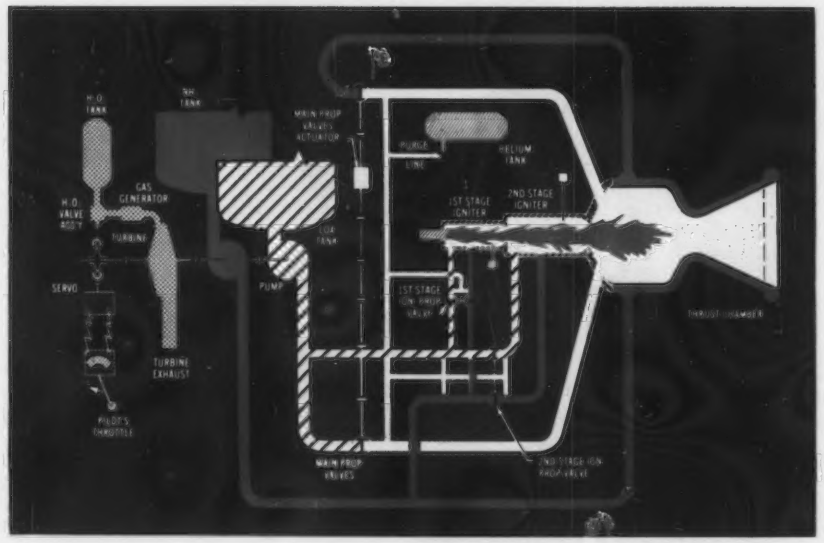
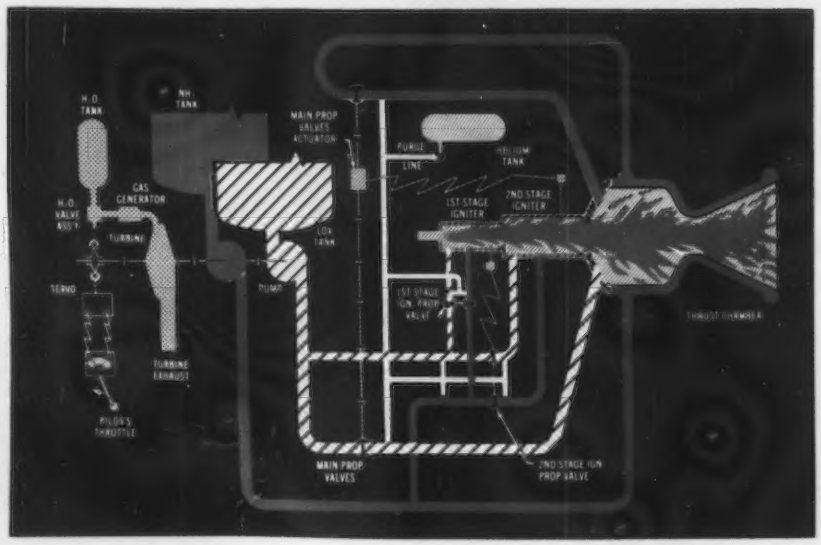


FIRST-STAGE IGNITER valves open if propellant pressure is adequate. Liquid oxygen is gasified in a heat exchanger before entering igniter. This makes first light-off safer. Eliminates dangerous build-up of propellants. Any one of three spark plugs gives adequate spark for light-off.

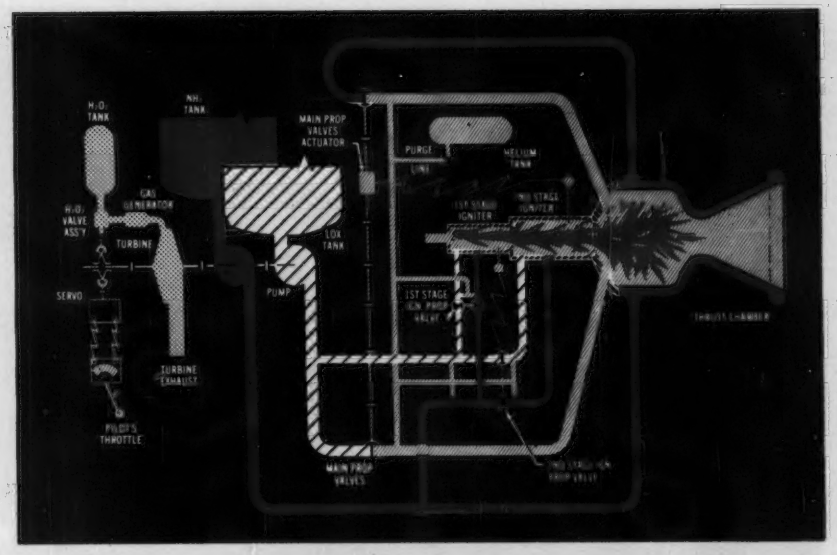


SECOND-STAGE IGNITER valves open on proper signal from first stage. Heat from first-stage igniter lights-off second stage. Flame passes through center port of hemispherical injector head into thrust chamber. Liquid oxygen cools walls of second-stage igniter.

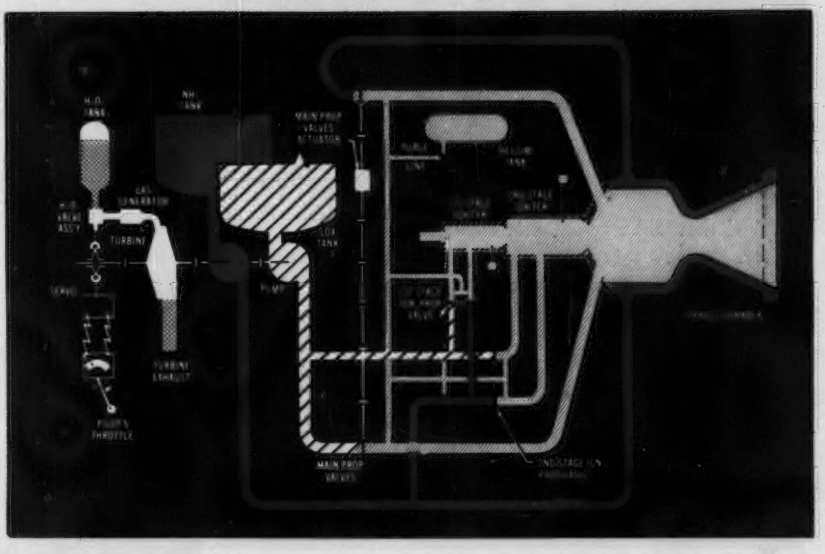


MAIN PROPELLANT-VALVES open on signal from second-stage igniter. Propellant starts to flow at 12,000 lb/min. At this rate, dangerous build-up of unburned propellant could occur in 1/200th sec. But constant heat source of igniters prevents this. Excess vaporizes and is blown off.

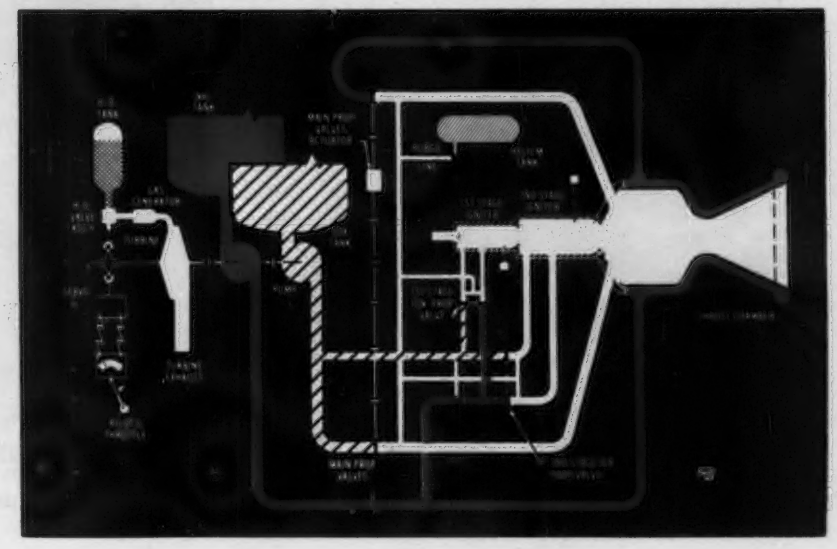
SHUT DOWN is initiated on pilot command when throttle is retarded. Main propellant-valves close and lines are immediately purged with helium. Continued combustion in the igniters burns off residual propellants, and helps clear engine.



IGNITERS ARE PURGED when combustion ceases in the thrust chamber. Helium is also used in purging the igniters. The sequence proceeds automatically once initiated. Engine is staged-down just as it is staged-up for safety.



SAFELY CLEARED of all propellants, engine is ready for restart. In flight, engine has capability for five complete start cycles. Limit is set by capacity of purging system. Engine can experience 100 start cycles and 1 hr of operation before overhaul.



Concentrated Hydrogen Peroxide
Liquid Ammonia
Liquid Oxygen
Helium

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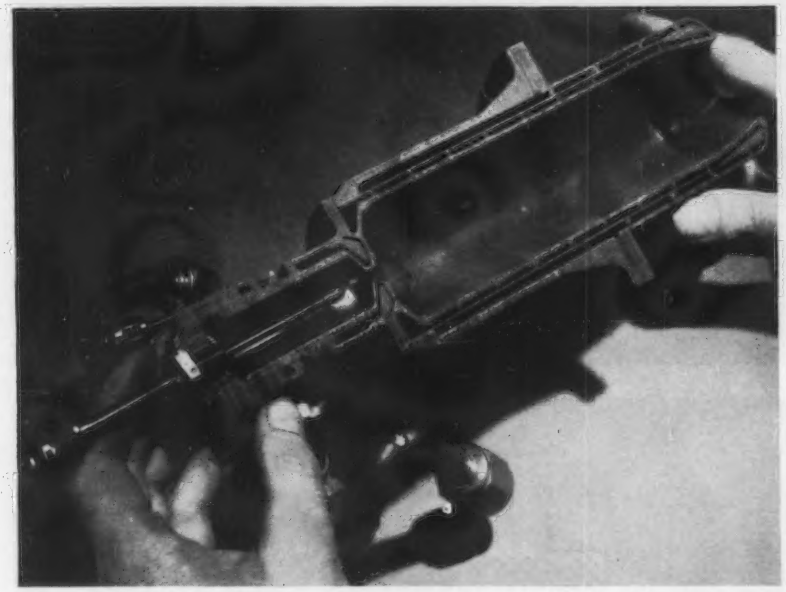
Hemispherical injector head allows propellant to be sprayed into hot flame of igniters

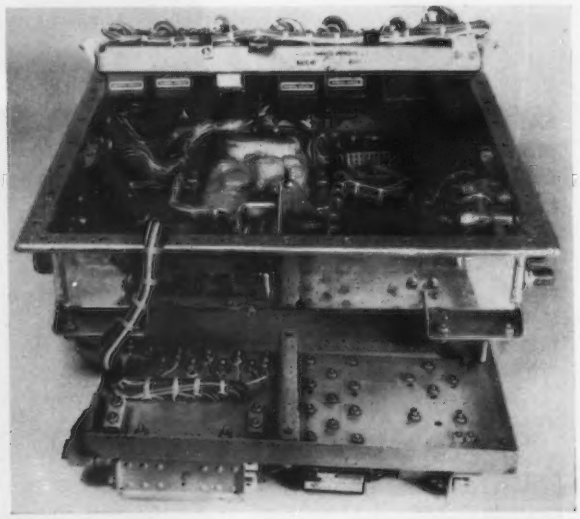


KEY COMPONENT in manned-safety concept of XLR-99 is two-stage igniter. By slowly building up heat source, chance of accumulating dangerous amount of unburned propellant is reduced. Oxygen is gasified before entering first stage. Gives safer initial light-off. Material is 347 stainless.

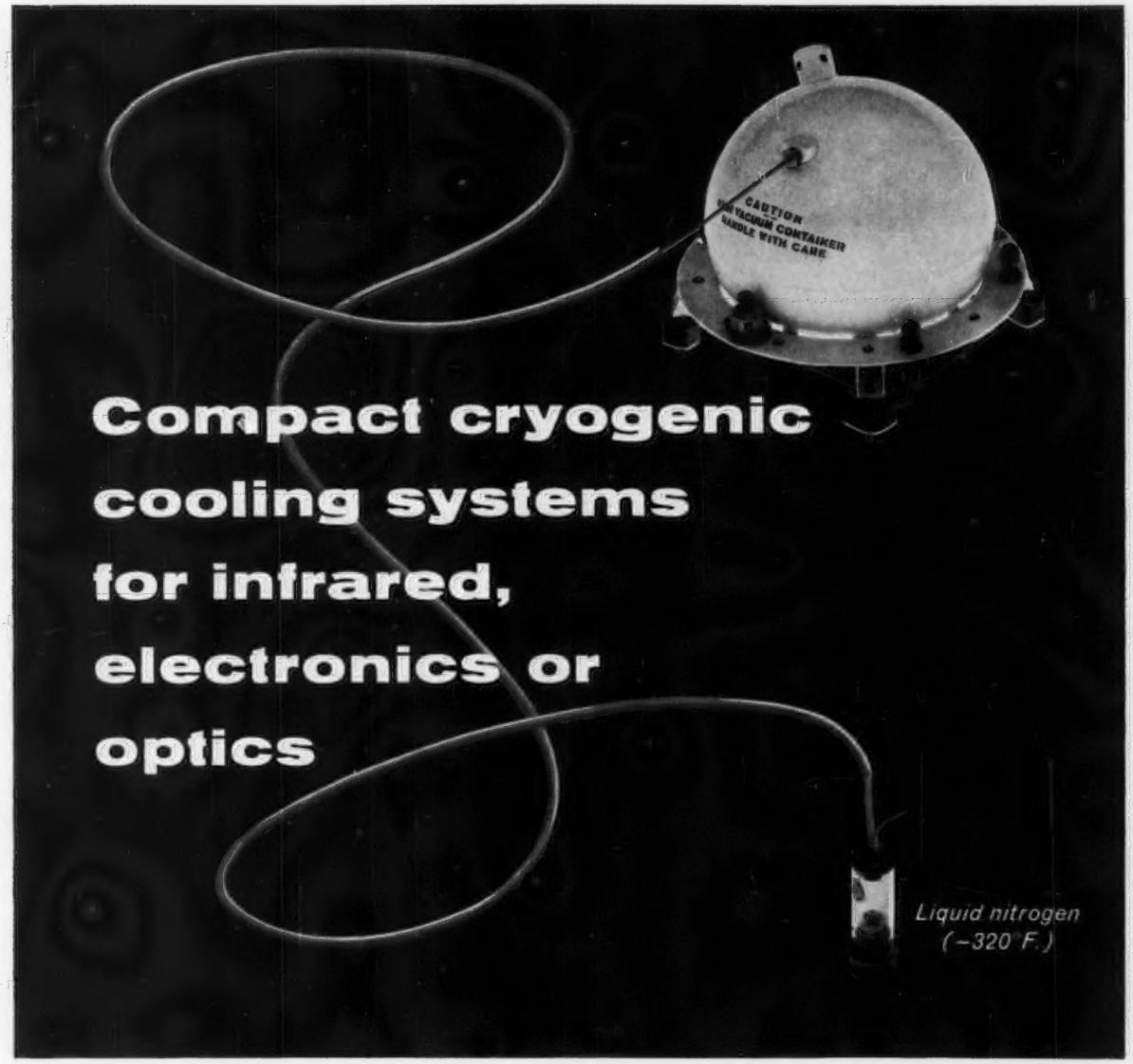
HEMISPHERICAL INJECTOR-HEAD adds to safety of XLR-99 by allowing main propellant flow to be injected directly in flame of igniters. Propellant must either vaporize or burn. Dome is Inconel X, sprayed with Rokide Z. Circular inserts are stainless steel, each has ports for O_2 and NH_3. Long canoe inserts are expansion fix.

A REPRINT
of this article can be obtained by writing on company letterhead to The Editor, AIRCRAFT & MISSILES, Chestnut & 56th Sts., Phila. 39, Pa.

MAIN PROPELLANT VALVES dump 200 lb of propellant per sec into thrust chamber. Valves open only when igniters give signal. Valves close as soon as manual or automatic shutdown signal is given. Valve is made by Hydromatics Inc.



CONTROL BOX that masterminds safety in the X-15's engine is made by Avionic Products Eng. Corp. Electronic circuits direct and monitor every phase of engine operation.



New AiResearch system delivers nitrogen in liquid form from storage system to cooling area

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AiResearch has pioneered many new developments in the cryogenic field. It is presently engaged in work on systems utilizing helium, hydrogen or neon as coolants, and cryogenic systems for zero G operation.

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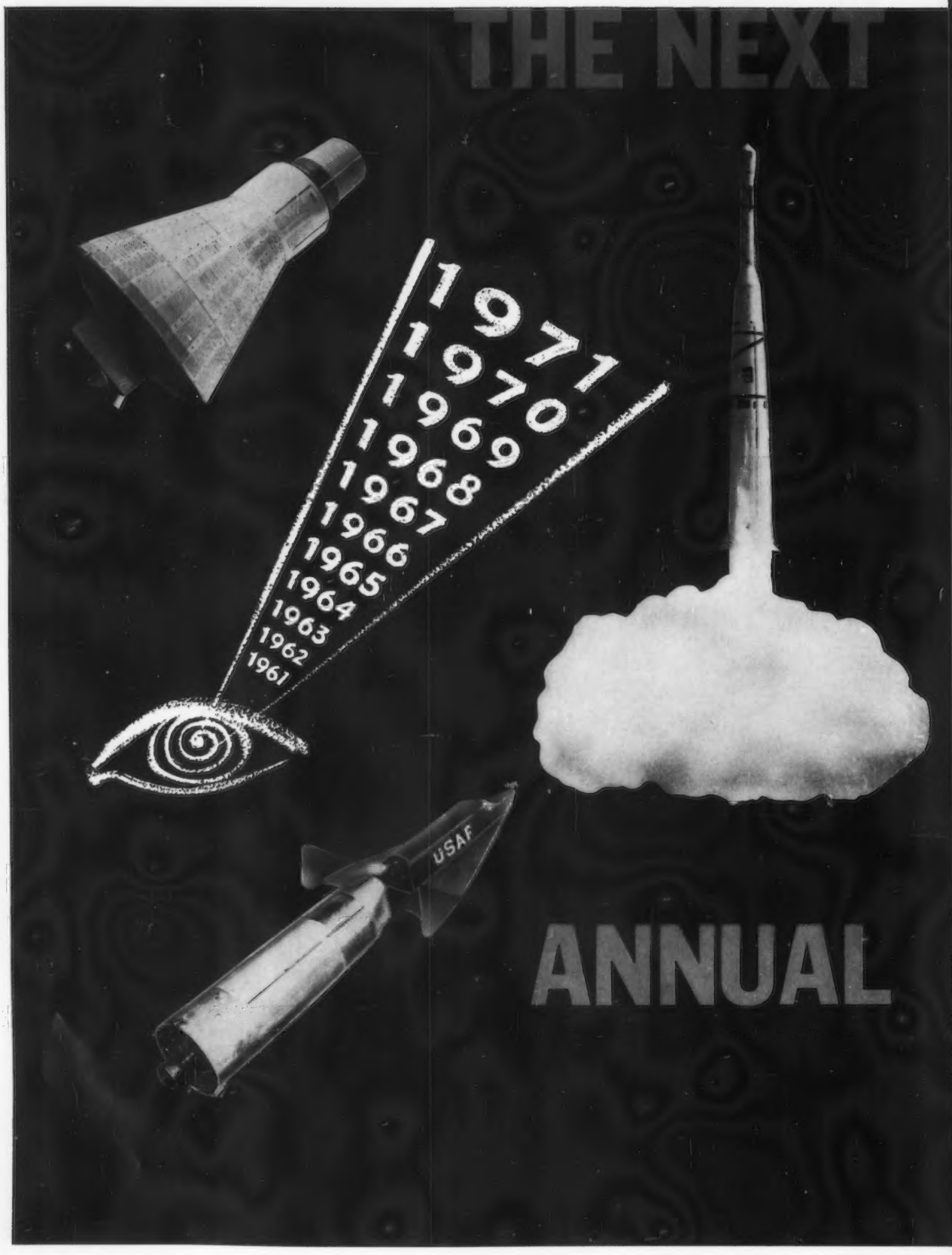
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TEN YEARS IN SPACE

JANUARY 1961 ISSUE OF AIRCRAFT & MISSILES

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PARTIAL LIST OF CONTENTS

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- NASA's Plan For Peaceful Space Exploration
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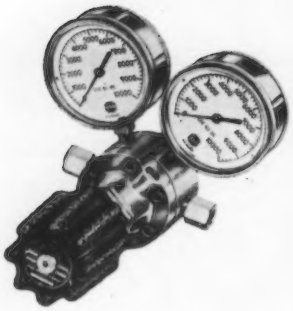

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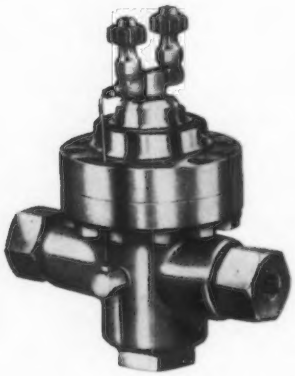

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Bristol Type 188 Aircraft

Designed for supersonic research; Has all-steel structure

By Ronald A. Cole

With an eye to the next generation transport concept, Bristol aircraft has designed the type 188 supersonic research aircraft. The 188 is comparatively large by research aircraft standards. It has a length of 71 ft, a span of 35 ft, and a wing area of 396 sq ft; it will carry extensive telemetry equipment.

The unusual wind planform incorporates a three-stage sweepback; none between the two nacelles, 38 deg outboard of nacelles, and 64 deg at the tips. Wing tips are movable since they constitute the aileron balance surfaces.

Nacelles will initially house de-Havilland Gyron Junior turbojets, but are designed for easy adaptation of other powerplants as well. For propulsion research, nacelles will be able to accommodate various intake designs. The Gyron Junior produces 10,000 lb static thrust, boosted to 14,000 by afterburner.

Stainless-steel construction accounts for about 90 per cent of the airframe. One alloy which promised to meet the specialized requirements of this aircraft was the Firth Vickers FV. 448 alloy with a 12 per cent chromium content. It had been previously developed as a creep-resistant turbine material in bar or forged form.

The FV. 448 alloy is now being used mainly as sheet stock which is milled or ground to size during manufacture; in bar form it has a tensile strength of about 156,000 to 190,000 psi, considered adequate for most fittings and forgings. However, an undisclosed type of steel in the range of 200,000 to 268,000 psi is used for wing pick-up forgings and fasteners.

Most of the exterior skin panels have a double curvature difficult to produce with the FV. 448 alloy. Hence, a cold-rolled material is used for this purpose. This is a titanium-stabilized, 19 per cent chromium, 9 per cent nickel alloy.

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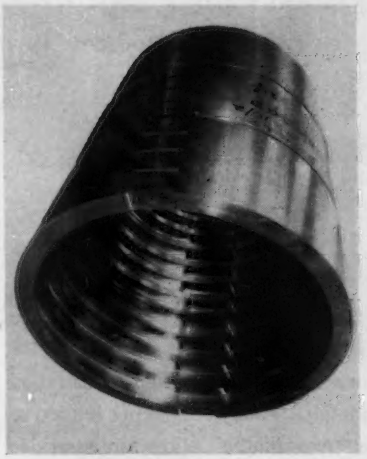
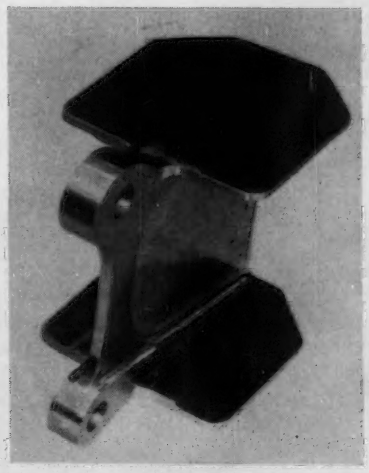


THREE CYLINDRICAL FORGINGS, with sculpture-milled ribbing and internal flanges, are bolted together to make up main portion of engine nacelles.



WING ATTACH FORGING for the 188 is made of an undisclosed alloy having a strength of 200,000 to 268,000 psi.

BRISTOL TYPE 188 supersonic research aircraft to probe domain of Mach 3 transport.

Working René 41 Into Your Design

Intriguing nickel-base alloy "re-born" in '41 at General Electric produced in sheet, wire, tubing, investment castings and large forgings; Mounting know-how is increasing applications in aerospace hardware

By S. Peter Kaprielyan

During its first decade of existence, René 41 was considered the maverick of high-temperature metals. Today it is being lauded as a "remarkable" alloy for a service range of 1000 to 1800°F.

Most recently, René 41 reached a new status by being accepted among the materials suitable for the Mercury capsule. Latest NASA plans call for using it to shield the capsule's conical afterbody and its antenna compartment.

TURBINE DISK FORGING of René 41 is shown being removed from the 50,000-ton closed-die press located at the Wyman-Gordon—USAF plant, North Grafton, Mass.

Introduced by General Electric, René 41 is a precipitation hardening, nickel-base austenitic alloy. It has been produced in hundreds of vacuum — melted heats by many vendors and converted to: sheet, foil, round and rectangular bar, rolled and flash-welded rings, wire, billet, closed-die forgings, rolled and welded tubing, and investment castings.

Nominal chemical composition of René 41 is as follows:

Element	Per Cent
Carbon	0.06-0.12
Silicon	0.5 (max)
Manganese	0.5 (max)
Iron	5.00 (max)
Chromium	18.00-20.00
Boron	0.01 (max)
Cobalt	10.00-12.00
Molybdenum	9.00-10.50
Titanium	3.00-3.30
Aluminum	1.40-1.60
Nickel	Balance (approx) 50.0

Heat Treatment — The alloy obtains its 180.000 psi uts at 1000°F through a two-step precipitation-hardening process: heating to 1975°F for 30 to 60 min, air cooling, re-heating to 1650°F for 4 hr, and air cooling again. First heat-treatment is solution treatment the second is the aging process.

René 41 is supplied in a mill-annealed condition and may be fabricated without further thermal conditioning. However, it often requires annealing during manufacture. This is done by heating to 1975°F for 30 min, then quenching quickly in oil. Quenching must be completed in 2 sec to obtain optimum ductility. Air cooled material has a rockwell hardness of C-30 with 31 per cent elongation in 2 in., while quick quenched material has a hardness of C-23 or less with elongation increased 45 per cent.

Annealing temperatures cannot be below 1975°F if full ductility is to be restored after work hardening. Cleaning the material after annealing and before further manufacturing is desirable. This is done by treatment in a virgo-type salt bath for 10 min, water quenching, then immersing in warm nitric-hydro fluoric pickle for 10 min.

Since warpage during heat treatment and through the air quench cycle is low, there is no need for fixturing for these operations. When annealing however, thin material tends to distort during quenching unless fixtured. Cylindrical and conical sections distort badly; they should be formed undersize prior to annealing, and then sized.

Fusion Welding—René 41 is fusion welded easily in its annealed or slightly cold-worked condition. For sound welds the Ryan Aeronautical Co. recommends accurate weld-joint fit up, good fixturing, and surface cleanliness. Cleaning solvents, vapor blasting (not sand blasting), emery cleaning or chemical descaling is used for this purpose; surface must be wiped clean just before welding.

LARGEST FORGING of René 41 was formed recently in the huge 50,000-ton closed-die press at the Wyman-Gordon Co., USAF plant. Two rings and a 34-in. wheel were cut, for rocket-engine use, from a 44-in. disk weighing 712 lb. Progress in René 41 producibility is measurable by the fact that in 1957 largest forging possible weighed only 4 lb.

Summary Of Techniques Used At Twin-Coach Co. For Welding And Heat Treating 0.064-in. René 41

CONDITIONS	AUTOMATIC WELD (without filler rod)	MANUAL WELD (with filler rod)
Arc Length	5/64 in.	1/16 in. approx
Electrode Diam	1/16 in.	1/16
Filler Rod Diam	(none used)	1/16
Current (DC Straight Polarity)	85 amp	110 amp
Welding Speed	13 in./min	13 in./min
Protective Atmosphere (Argon—cu ft/hr)	20 at electrode 10 at backup plate	20 at electrode 20 at backup and clamping bars
Solution Temp	1950°F—1/2 hr	1950°F—1/2 hr
Quench	Water	Water
Aging Temp	1400°F—16 hr	1400°F—16 hr
Quench	Air	Air

Rapid cooling of weld area is accomplished by copper back-up bars or water-cooled welding fixtures. High quality welds are produced using d-c power, argon gas shielding, and back-up bars. Both manual and machine welds, with or without the application of René 41 filler material are possible, but machine welding should be used whenever feasible.

René 41 filler wire is available but it is not necessary for achieving high strength joints. The best inert-arc weld-filler material used with René 41 for "low" temperature applications (to 1400°F), is Hastelloy W; for high temperature components (above 1400°F), it is Hastelloy X. The latter is necessary at the higher temperatures because of the increased oxidation resistance

René 41 is fusion or resistance-welded in annealed or slightly-coldworked state

supplied by the higher chromium content (22 per cent vs. 5 per cent Cr). A comprehensive evaluation of various fillers, at General Electric, Cincinnati, showed that flush square-butt joints welded with Hastelloy W and Hastelloy X had 80 to 85 per cent of the parent metal strength and good ductility as measured by tensile tests from room temperature to 1600°F. This apparent anomaly of weaker materials (Hastelloy W and X) showing high joint strengths can be explained by the fact that during welding they melt, flow readily, and are strengthened by dilution with the René 41. Many other filler materials do not possess these desirable characteristics.

Welding aged René 41 is virtually impossible. The surest and cheapest way to build a part which will have the strength capabilities inherent in the alloy is to do-it-right-the-first-time. If any major cracks appear after aging, the part will have to be annealed prior to repair welding. Work is now underway to devise special techniques which will permit at least a limited amount of welding on aged material.

Gas backing is mandatory on all butt joints. Keeping the molten weld-metal protected from atmospheric contamination cannot be too strongly emphasized. Filler welds on sheet stock less than 0.030 in. that cannot be both metal and gas backed will inevitably lead to cracks and/or "burn thru." Butt joints that are not gas-backed will show an oxide line at the root of the weld bead.

The material must not be welded in a stressed or aged condition, except when making weld repairs after aging. Welding may be done after mild forming operations without an intermediate anneal.

Favorable results in welding and heat treating René 41 have also been reported by the Twin-Coach Co. Work in this case involved only 0.064-in. sheet, but the measure of success achieved indicated that with proper coordination and control of welding variables and post heat treatment, joint strengths having 100 per cent efficiency may be realized with other gages also. Details of the techniques used at Twin-Coach are outlined in an accompanying table.

Resistance Welding — As with fusion welding, resistance welding of René 41 is done with the material in the annealed or slightly-cold-worked condition. It must be clean, free of scale and oily substances. The material is extremely "splash" sensitive, but this can be minimized by a tight fit between faying surfaces. Weld deficiencies of major concern are voids, splashing, oxide inclusion and insufficient nugget size and penetration.

For satisfactory welds, high tip-pressures with accompanying low weld-times are required. In some cases it has been necessary to introduce a pre-weld compression and post-weld forge to obtain quality welds.

Repair Welding — Through a cooperative program between GE's Aircraft Gas Turbine Division and the Battelle Memorial Institute a study was made of repair-welding René 41. Repair welding is used for mending welded parts which develop cracks after aging heat treatment. This cracking occurs mostly in the weld of highly-restrained parts, and more often in the base metal itself.

Two types of materials were investigated: René 41 of standard composition, with a low boron-content, and a low-carbon variety with higher boron-content. Sheet thicknesses were 0.030, 0.045, 0.060, and 0.075 in. Filler material in these experiments were either René 41 sheared strip, Hastelloy "X", or Hastelloy "W" wires. Most of the welding was done with Hastelloy "W" filler. All welds were made manually by inert-gas-shielded tungsten-arc, using direct current, straight polarity.

The results indicated that hammer peening at room-temperature or a localized solution-treatment (at 1950°F) of repair-welded material increases the service life of René 41 weldments subjected to simulated jet-engine service conditions.

Additional studies were made to determine to what extent René 41 properties were affected by thermal cycling, such as would occur under certain flight conditions. Conclusions reported by Battelle are as follows:

(1) A moderate loss in tensile properties occured in René 41 cycled between 1350°F and 1750°F or 1875°F. The damaging mechanism at 1750°F was overaging; at 1875°F, the damage mechanism was resolution of the gamma prime precipitate and alloy depletion.

(2) No losses in stress-rupture properties were observed in René 41 cycled between 1350°F and 1750°F. Only slight decreases in stress-rupture lines were noted in material cycled between 1350°F and 1875°F. This decrease is attributed principally to alloy depletion.

Brazing—The Brazing of René 41 has been complicated by the fact that most high-temperature braze alloys are nickel-base materials containing boron and/or silicon which severely attack the alloy intergranularly. Silver brazes do not attack René 41, but they are limited to low temperatures (600°F) which would seriously limit the applications of the alloy. Any brazing on René 41 must be done in a hydrogen atmosphere or in vacuum to prevent surface oxidation of the aluminum and titanium present in the alloy. These oxides prevent a high-strength bond.

Nickel plating before brazing tends to eliminate the erosive and embrittling effects of boron-containing alloys on René 41. Failure, however, occurs in shear through the plating resulting in low-strength

values. Efforts are underway toward development of boron-free high-temperature brazing alloys that would not erode or embrittle René 41.

Forming — Experience gained at Ryan indicates that René 41 has essentially the same forming characteristics as 18-8 and other nickel alloys. However, it has a greater resistance to forming. It is recommended that all forming be done in the annealed condition (Rockwell C-25 or lower). In this condition, it is quite ductile and forms readily on the drop hammer, expanding mandrel, stretch former and on class "A" dies on the punch press. However, due to its lack of compressibility, compression flanges wrinkle when formed on a bladder-type press. Tests indicate that this type of forming should be avoided unless some means of trapping and drawing flanges are developed. Straight flanges will form satisfactorily, but have a spring-back of 8 to 10 deg. Although this material does not appear to work-harden readily, it may be necessary to form in several stages whenever severe forms are attempted. In these cases, annealing is required between stages.

Cutting And Parting—René 41 cannot be cut on slow-speed saws; it requires high-speed saws which cut by a friction process.

Shearing is less of a problem and can be done at room temperature with either square or rotary shears. In its ability to be sheared, René 41 is comparable to 18-8 stainless steel. It is not necessary to remove areas adjacent to the sheared edge prior to welding as is sometimes the case with other super alloys.

Punching and drilling must be used to obtain circular openings, since a hole saw is highly unsatisfactory. Drilling may be done in either the annealed or aged condition without difficulty.

Machining—René 41 is a less machinable than Inconel X, and wears tools easily. Ryan feels that high-speed steel cutters (T-15 series) seem to have advantages over carbide tip cutters in milling operations although carbide cutters are satisfactory for lathe work.

Parts which have been machined should be rockwell hardness tested. If readings of C-28 or higher are found, the parts should be annealed before further fabrication.

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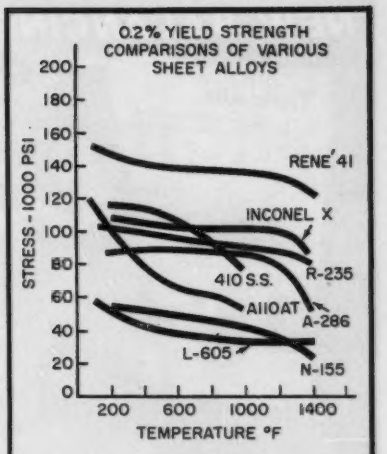

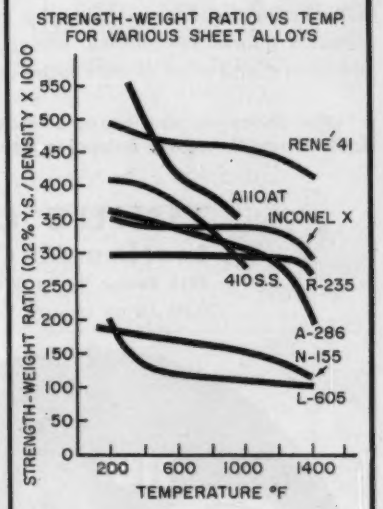

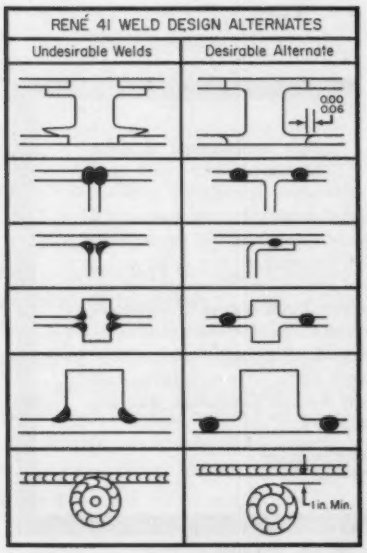

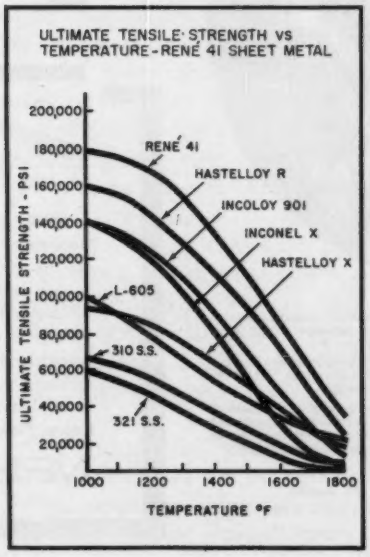

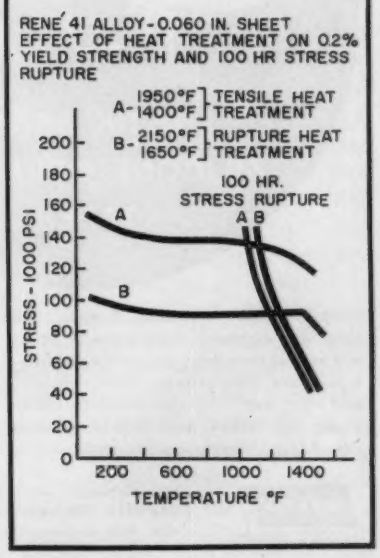
RENÉ 41 ALLOY - 0.060 IN. SHEET
EFFECT OF HEAT TREATMENT ON 0.2%
YIELD STRENGTH AND 100 HR STRESS
RUPTURE
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B - 2150°F / 1650°F RUPTURE HEAT TREATMENT
100 HR.
STRESS RUPTURE
STRESS - 1000 PSI
TEMPERATURE °F
A
B

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Circle 22 on Inquiry Card

Molecular Engineering For Electronics

By Fred P. Granger, Jr.,
Director of Microcircuitry,
Varo Manufacturing Co., Inc.

Small components built up molecule by molecule; Long-range goal is unitary electronic structures equivalent to thousands of individual components

Microcircuitry is the technology of designing and fabricating electronic devices from the basic particles of matter. Optimum arrangement of the particles can give predetermined electrical transfer functions.

Fabrication proceeds directly from the particles of matter to the functional device. No connections or assembly operations are involved. Some have called this technology molecular engineering.

Microcircuitry combines the knowledge and skills of physicist chemist, metallurgist, mathematician, and electronics engineer. Its long range goal is the fabrication of electronic structures whose functions are equivalent of assemblies of hundreds or even thousands of components. Short range goal is the control of the structure and behavior of combinations of thin film materials which exhibit specific classical electrical characteristics.

Need for Processes—In the thin film state-of-the-art of microcircuitry, films must be made to exhibit stable and predetermined characteristics, and be physically, thermally, electrically and chemically compatible. Identical or closely related processes must provide for their fabrication. Controlled evaporation and deposition of materials in vacuo offer the best possibilities for the fabrication of structures of single or multiple elements. With the processes developed for the control of material purity structure, and bonding with other films, old materials take on a new look in microcircuitry.

Conductors—Let us first look at simple conductors. The conductivity of silver, copper, aluminum, and gold is in the order listed. For conventional applications, copper is normally used because it is less costly than silver. Aluminum is frequently selected as a compromise because its weight is less than copper.

In microcircuitry, because of the small amounts required, the cost of the material becomes a negligible factor. Silver, which would appear to make an ideal conductor, exhibits several undesirable characteristics. In thin films, silver tends to migrate and it tarnishes easily. Subsequent deposits are made difficult. Its compatibility with other materials used for resistance, inductance and semiconductors is relatively poor. Aluminum is relatively stable, but oxidizes easily as does copper.

Gold is a good compromise for conductors. Though most expensive of the materials considered and having the lowest conductivity, the cost and the resistance of conducting paths are very low because of the small dimensions involved. Gold is stable, relatively inert, and is generally compatible with other microcircuitry materials. It is normally used in films about 1000 Å thick.

Resistors—Next, let us consider resistive materials. Requirements will be restricted to resistance elements whose value is stable with time, temperature and applied voltage.

In conventional components a variety of materials are used for resistors. So-called composition resistors satisfy most general purpose applications. Wire-wound resistors are used where low noise characteristics are necessary, or for large power dissipation, etc.

In microcircuitry it is desirable to use a single material and to control the geometry or structure to obtain the desired characteristics. In films it is convenient to consider resistivity in ohms per square. The resistance of a given film is the product of its resistivity in ohms/square and the ratio of the length to width of the film. For very large resistance values, a large resistance/square permits the use of a film with reasonable length to width ratio. Conversely, for resistance values of a few thousand ohms or less, a low resistivity is preferable. A reasonable compromise which provides for a variety of circuit requirements is a resistivity of from 1000 to 2000 ohms/square.

Resistor Materials—A number of individual elements, alloys and compounds have been investigated as possible resistive materials for microcircuitry. The most acceptable compromise, at present, is exhibited by nichrome. A film of nichrome, a few hundred angstroms thick, has a resistivity of approximately 1000 ohms/square. It can be made stable so that change over thousands of hours of storage or operation is less than 1 per cent. Temperature coefficient of resistance is less than 100 parts per million per degree centigrade over a range of temperature from —55 to +150°C. Thermal noise in such nichrome films is but slightly greater than for a good wire-wound resistor. Excess current noise is comparable to that

How to select electronic materials for microcircuitry applications

in a good composition resistor.

Nichrome films in this range are hard and durable. Up to 30 watts per in. may be dissipated without catastrophic failure. Nichrome adheres well to glass or ceramic substrates as well as most other microcircuitry materials.

Pulse Electron Bombardment— Successful deposition of nichrome resistance films requires that evaporation be accomplished without fractionization, otherwise, the ratio of nickel and chrome in the films would vary from deposition to deposition. This is aided at Varo Mfg. by pulsed electron bombardment of the nichrome material. Formation of a stable polycrystalline structure is accomplished by precise control of the rate of deposition and of the temperature of the substrate on which the film is deposited.

When a film of nichrome is first deposited, the individual condensed particles may still be mobile and a stable structure is not attained for a period of time which is a function of several factors including substrate temperature and film thickness. It has been determined that oxidation of the surface occurs readily, but forms a hard oxide film a few angstroms thick. This surface oxidation, of course, increases the resistance of the total resistance film. Both the effect of structural change after the end of deposition and surface oxidation may be predicted with reasonable accuracy. Dynamic measurement of resistance may be made during deposition to make possible precise control of the deposited film resistance.

Dielectric Materials — Deposition of dielectric materials poses several problems, the most important of which is the tendency for pinholes to form. Subsequent deposited metals penetrate the pinholes and cause the capacitor or insulator to exhibit a very low resistance. Ideally, dielectric material for use in the formation of a deposited capacitor should have a high dielectric constant, dielectric strength and resistivity, and low dissipation factor. For use as an insulator the dielectric constant should be very low.

The oxides of silicon exhibit useful dielectric properties. Silicon alone is metallic in nature, but has a high resistivity. If a deposited film of silicon monoxide is coated with a thin deposit of silicon, the silicon penetrates the pinholes and appears to become oxidized. The resultant dielectric film has good dielectric properties and is free of pinholes. Dielectric constant is approximately 4, while dielectric strength is greater than 5000 volts/mil. Resistivity of the silicon monoxide is in the order of 10^{12} ohm-cm. Dissipation factor of deposited SiO capacitors is less than 0.01.

Although high dielectric constant is desired, SiO capacitors of relatively large value can be fabricated by multiple layer techniques. The capability of depositing pinhole free dielectric films makes feasible the deposition of complex passive networks, and multiple layers of such networks on a single substrate.

The successful deposition of dielectric films with the Si-SiO combination requires precise control of rate of deposition, absolute thickness of the composite film and relative thickness of the films of SiO and silicon. Most techniques for measurement of film thickness either have accuracy limits of 5 per cent or more, or require extensive apparatus and tedious calculations. Varo has adapted the technique of measuring the change in frequency of a crystal resulting from the increased mass of a deposited film on the crystal surface into the vacuum deposition control process. Change in frequency of the crystal is linear over a wide range of film thickness and is in the order of 1 cps per angstrom of deposited film. Calibration of the crystal is made by measurement of film with interferometer methods. Control of relative film thickness can be maintained to within 1 or 2 per cent, and by measuring the change in frequency with respect to time, the rate of deposition can be measured and hence controlled.

Control of material to provide active functions is less advanced. Many efforts are under way. Some progress has been reported. The formation of thin film single crystal semiconductor material has been attained through the processes of epitaxy. Such techniques are a step forward toward more complete control of material and may lead to knowledge sufficient to permit the fabrication of semiconductor single crystals without a single crystal substrate.

Applications — What applications use microcircuitry devices? At this time, actual semiconductor components must be assembled to the films comprising the passive circuitry. With the material listed, any circuit not requiring inductance or large values of capacitance can be fabricated. In particular, digital and radio frequency circuits are within established microcircuitry capability. In the military environment, the limiting portion of a device is normally the semiconductor and its temperature limit. Computers, guidance systems, communication and telemetry systems are typical applications suited to today's state-of-the-art of microcircuitry. Compromise may be required, and, to accomplish special functions, conventional components may be used. To a large degree, however, it is feasible to fabricate devices which are smaller by orders of magnitude and inherently more reliable than a component assembly.

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Aerospace Demands Spur Brazing Advances

Liquid rocket chambers are prime movers for process development in hi-temp joinings; Five basic designs bank heavily on brazing

By G. D. Cremer, R. S. Mueller, J. C. McGhee
Engineering Dept., Solar Aircraft Co.,
Subsidiary of International Harvester Co.

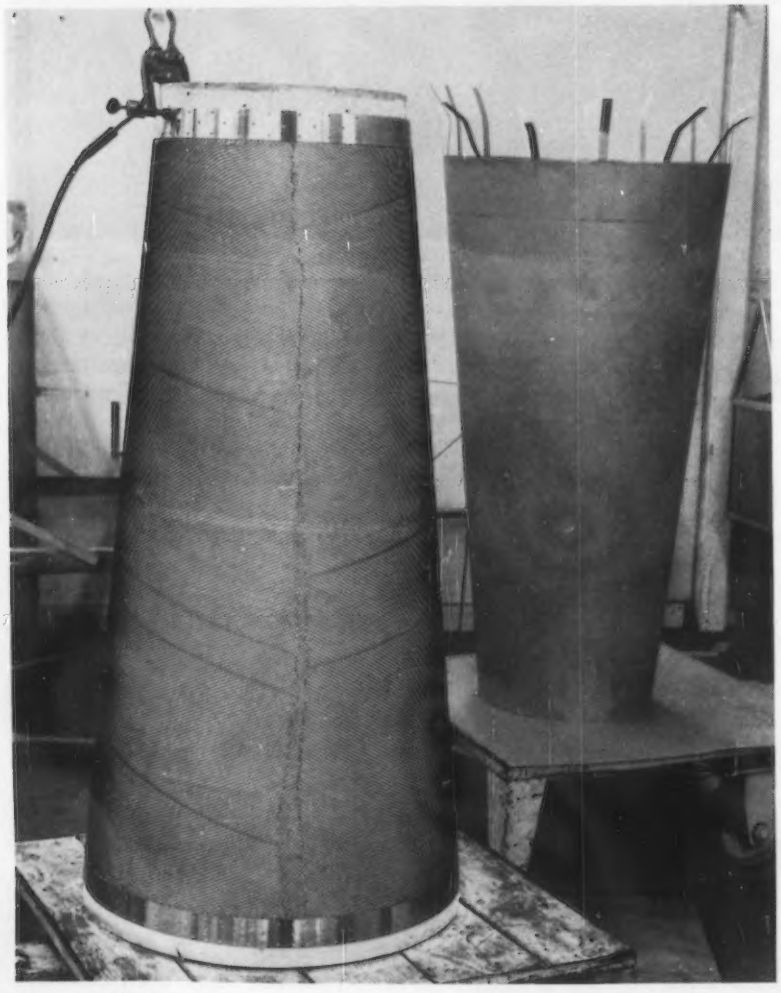

FIG. 1. NOSE CONE sections of brazed honeycomb are receiving attention by weight-conscious designers. Frustum shown was fabricated for McDonnell from Haynes L-605.

An exciting, new field for brazing is being catalyzed by the demands of rocket powerplants. Missiles and space vehicles are also adding to the momentum of brazing developments.

One technique advance has been the braze joining of molybdenum (4750°F melt point) and tungsten (6100°F melt point). Under laboratory conditions good joints have been achieved using chromium (3430°F melt point) and tantalum (5400°F melt point) respectively as filler metals. These techniques will have direct application in an ion rocket engine.

The hibernating F-108 and the awakening B-70 opened many doors in manufacturing brazed honeycomb structures for service exposure of 500 to 600°F.

Several missile requirements have led to production of structures which hold strength to 1800°F. A typical airframe part is shown in Fig. 1. It is a conical section produced for evaluation by McDonnell. Core material is Haynes Alloy 25 (L-605) with 0.0015 x 3/16 in. square cell. The core is wrapped snugly about the 0.012 in. inner sandwich facing, also of L-605. End flanges are attached to the honeycomb with spot welds. The outer facing is pulled tightly over the core-mandrel assembly, secured and furnace brazed. Brazing takes place at 2100°F in dry hydrogen.

Brazing alloy is corrosion resistant nickel-chromium iron-boron powder.

Rocket Chamber Designs—The liquid rocket combustion-chamber has probably offered brazing specialists the greatest opportunity to display their talents.

Large chambers consume a prodigious amount of fuel and generate temperatures between 5000° and 7000°F depending on fuel-oxidizer combination. By constructing the chamber with hollow walls and pumping the high volume of liquid propellant through the walls, a giant heat exchanger results. It cools the chamber, preheats the propellant and results in efficient performance.

Brazing has been used widely in five basic regeneratively cooled thrust chamber designs.

- Spiral Tube
- Tube Wall
- Ribbon-Wrapped Channel
- Wire-Wrapped Rib-Wall
- "Plug" Type (experimental)

All are shown in Fig. 2.

The Tube Wall—Most of today's large liquid engines are of the tube wall type. They have become known as "brazed spaghetti chambers." Thor, Atlas, and Titan use this kind of chamber. The new X-15 engine also uses this design, as does the 1.5 million lb thrust booster now under development.

NASA's 6000 lb thrust engine, intended originally for the third stage of Vega, is an example of the "spaghetti chamber."

In this engine, 111 precision-swaged and formed T-347 stainless steel tubes are tightly assembled over a mandrel. The support mandrel accurately provides the internal dimensions of the chamber. Tubes are braze joined in a furnace in several cycles. The first cycle (see Fig. 3) joins tubes, stiffener flanges, and base ring for the return manifold.

For the second cycle, the unit is inverted and no mandrel is used. Inverting promotes braze alloy flow for joining and sealing the inlet manifold assembly. Additional braze alloy is added in areas where minor voids between tubes result in the first braze cycle.

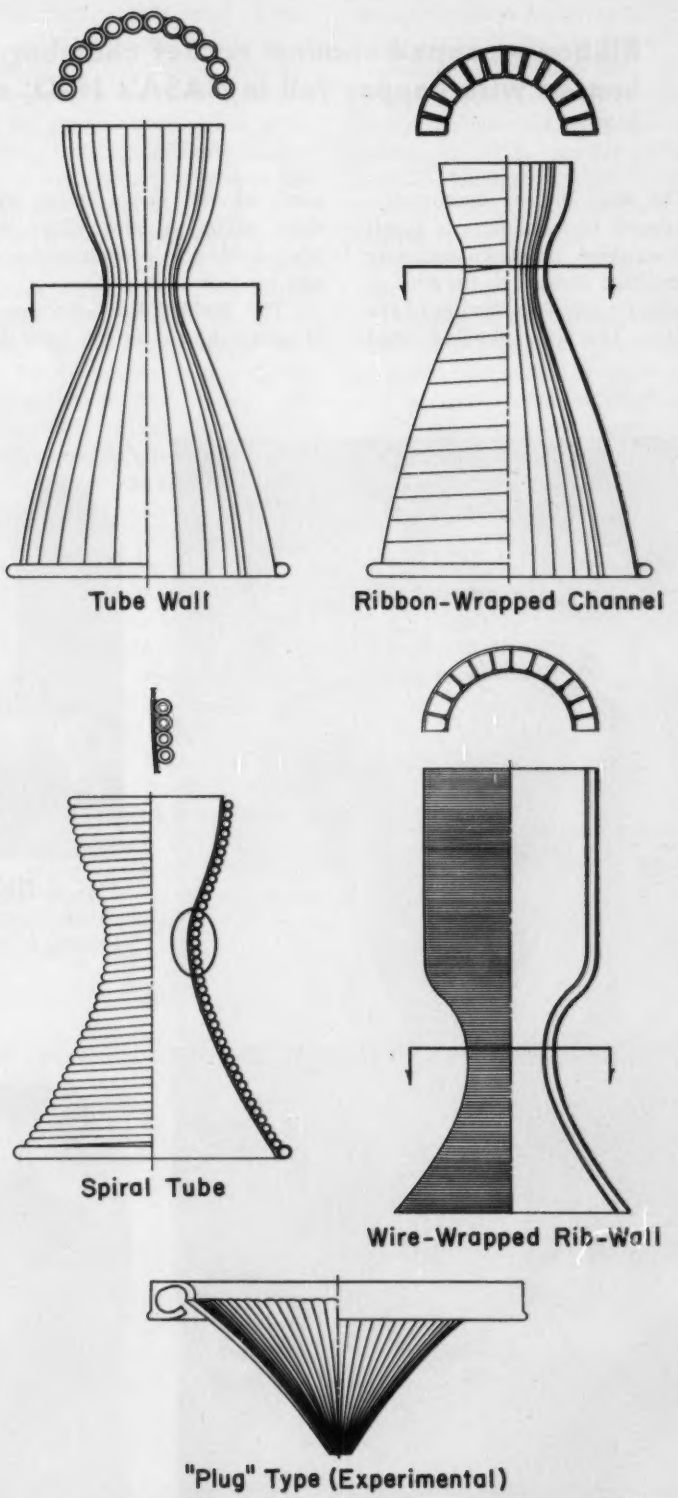

Fig. 2 FIVE THRUST CHAMBER DESIGNS comprise the basic types in liquid fuelled rocket motors. All use brazing to some extent.

Ribbon-wrapped channel rocket chamber brazed with copper foil in NASA's H_2-O_2 engine

The final brazing operation is at reduced temperature. It bonds spiral-wrapped stainless steel wire at tangential contact to the tops of the tube on the skirt section of the chamber. The last remaining detail part, an exit nickel frame shield skirt, utilizes a nickel-filler braze alloy mixture to provide attachment and gas-tight seal.

The Welded Rib—Another interesting design at Jet Propulsion Laboratory uses wire-wrapped welded-rib construction (Fig. 4). A fundamental design requirement is high-strength joints between inner facing, rib wall, and wire wrap. In addition, sealing between adjacent

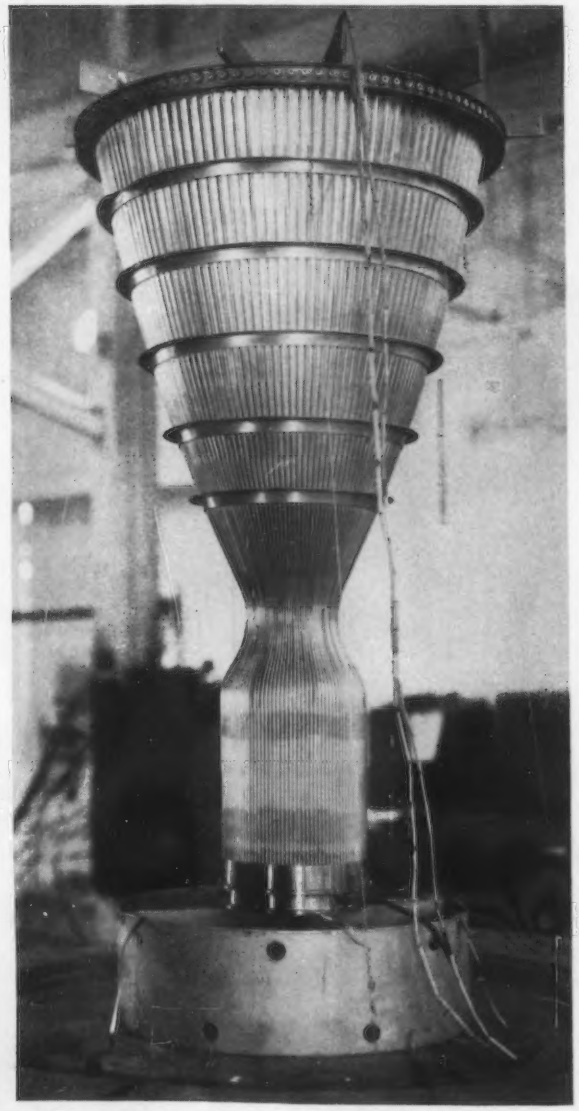

FIG. 3. VEGA ENGINE (NASA's 6000 lb thrust program) uses tube-wall design. Tubes are T-347 stainless steel. Three furnace brazing cycles are used.

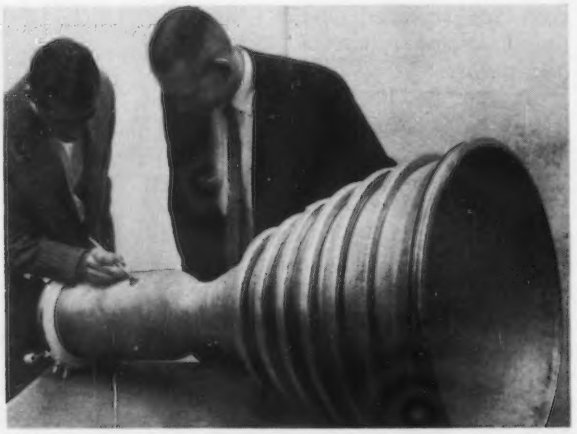

FIG. 4. HIGH-STRENGTH CHAMBER can be constructed using wire-wrapped welded-rib construction. Brazing is used to join thin walled materials.

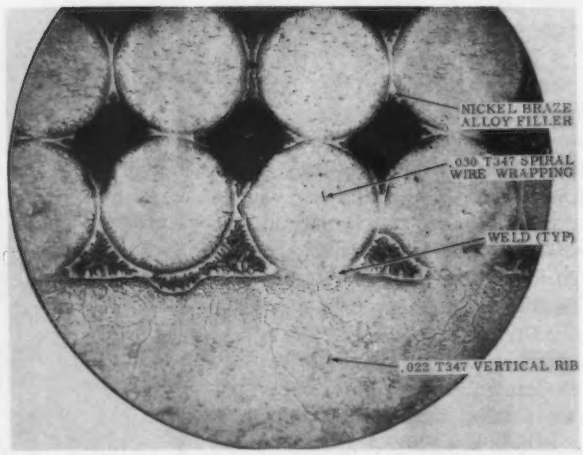

FIG. 5. EXCEPTIONAL BONDING characteristics of braze alloy used in high-strength chamber can be seen in photomicrograph.

wire turns must be complete.

The photograph (Fig. 5) shows the exceptional bonding characteristics of the braze alloy used.

A precision-formed 0.015-in. inner shell or facing is used as the foundation. Eighty full-length, 0.022-in. thick longitudinal ribs are then accurately positioned against the shell surface and resistance-welded in place. Corrosion-resistant nickel-chromium brazing alloy powder is applied to the "Tee" joint of each rib. A volatile binder secures the brazing material, then a high-temperature furnace-brazing operation completes the first cycle.

Prime virtue of this welded and brazed rib construction is that variations of vertical rib height and spacing permit wide latitude in design. It is a relatively simple matter to change passage area for adjusting fluid flow rate, pressures, and heat transfer requirements.

Closure of the fluid passage is accomplished by utilizing a continuous spiral of 0.030 in. wire wrapping contacting the tops of the previously brazed ribs. Complete sealing between the 5000 ft of wire strand and bonding to the tops of the ribs is accomplished by using a nickel-base, high-temperature brazing alloy.

The final furnace brazing cycle is used to braze the manifold rings and the skirt support rings. Penetrant inspection and pressurization is used to test for leakage. Welded-rib, wire-wrap method of thrust chamber manufacture shows great promise. Pressure tests of fluid passages at over 2000 psi attest to this remarkable strength.

The Ribbon Wrap—NASA has created a unique concept of design-materials-fabrication of a thrust chamber which involves the use of stainless-steel sheet-metal channels. They are ribbon-wrapped and then integrated by furnace brazing. This regeneratively cooled chamber has been designed to efficiently conduct heat away from the thin metal liner by varying the velocity of the fuel coolant to meet heat conditions. The sheet-metal channels provide an easy, yet precise method for controlling coolant passage area throughout the chamber. NASA's hydrogen-oxygen-chamber design is particularly well suited to this light-gage metal fabrication.

Fig. 6 shows a chamber in the process of being ribbon-wrapped. Three hundred and sixty stainless-steel "U" channels 0.008-in. thick have been assembled in barrel-stave manner and fastened to one another by approximately 100,000 resistance tack welds. Electrical machining techniques have proven most effective in achieving precision height-sizing of the channel legs.

Ribbon wrapping consists of roll forming 0.008-in. thick steel ribbon to give an interlocking tongue-and-groove fit when spirally wound. Copper brazing foil 0.001 in. thick is simultaneously fed underneath the formed ribbon as it is stretch-wrapped about the chamber contour.

Brazing is first accomplished at 2050°F in a protective atmosphere to insure immaculate metal surfaces and promote complete braze flow.

Brazing is likely to continue as the predominant method of manufacture for lightweight, regeneratively cooled thrust chambers. There is evidence that an engine of two-million pounds thrust is practical; when plug-type engines are considered, thrusts of 5 to 10 million pounds are feasible.

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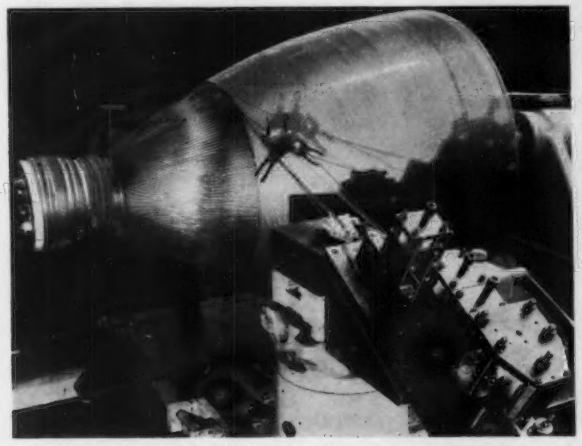
Fig. 6. RIBBON WRAPPED CHAMBER is comprised of 360 stainless "U" channels positioned by 100,000 tack welds. Wrapping process (in photo) gives tongue and groove fit to 0.008-in. steel ribbon.



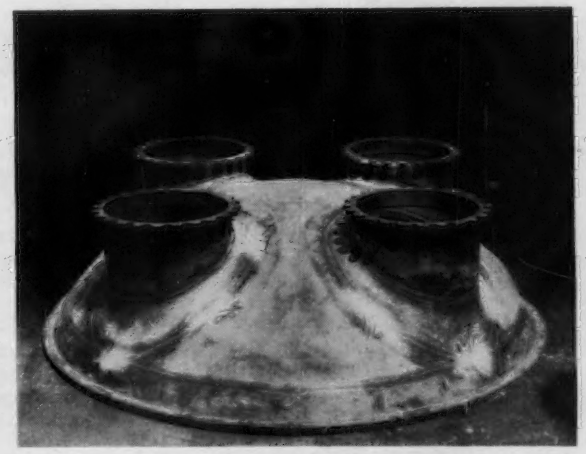


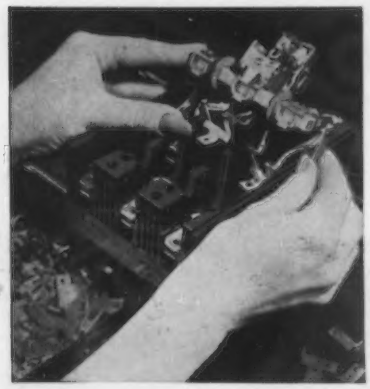
FIG. 7. BRAZED NOZZLE FLANGE INSERTS solved problem for early first-stage Minuteman. T-422M inserts were brazed in H-11 steel flanges. After heat treat, softer inserts could be drilled and tapped with speed and precision.

Important facts to know about Laminated Plastics

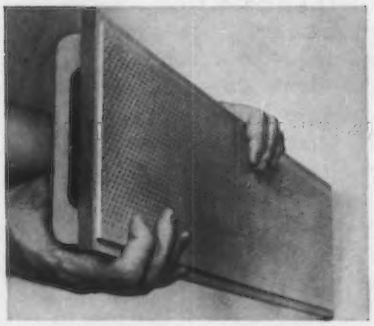
LAMINATED PLASTICS *What they are, where they can be used*

Taylor laminated plastics, also known as reinforced plastics, are thermosetting-type materials formed by impregnating paper, cotton cloth, asbestos, glass cloth, nylon or other base materials with synthetic resins and fusing them into sheets, rods, tubes and special shapes under heat and pressure. These materials exhibit a valuable combination of characteristics, including high electrical insulation resistance, structural strength, strength-to-weight ratio, and resistance to chemical reaction; also adaptability to fabricating operations.

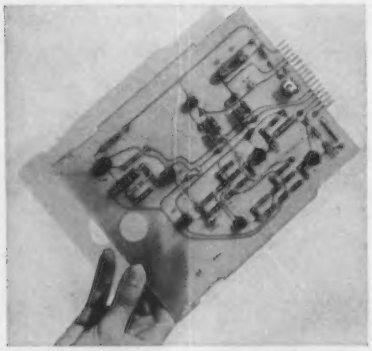
Types of laminated plastics made by Taylor
There are four basic types of Taylor laminated plastics commonly specified and used throughout industry today. They are as follows:



Phenolic Laminates. Paper, cotton fabric or mat, asbestos, glass cloth or nylon bases impregnated with phenol formaldehyde resins. These provide strength and rigidity, dimensional stability, resistance to heat, chemical resistance, and good dielectric characteristics. Some Taylor grades are excellent basic materials for gears, cams, pinions, bearings and other mechanical applications. Others are widely used in terminal boards, switchgear, circuit breakers, switches, electrical appliances and motors. Also in radios, television equipment and other electronic devices; and in missiles as nose cones, exhaust nozzles, and combustion chamber liners.

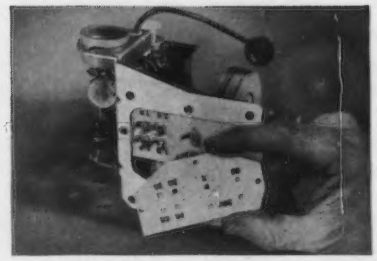


Melamine Laminates. Glass cloth or cotton fabric impregnated with melamine formaldehyde resin. Taylor melamine laminates have superior mechanical strength and are especially desirable for their arc-resistant qualities. Good flame and heat resistance, good resistance to the corrosive effects of alkalis and most other common solvents, besides other favorable characteristics. Typical applications include arc barriers, switchboard panels, and circuit-breaker parts in electrical installations.



Silicone Laminates. Continuous-filament woven glass fabric impregnated with a silicone resin. These laminates combine high heat resistance (up to 500°F. continuous) with excellent electrical and mechanical properties. They are primarily used in high-temperature electrical applications and high-frequency radio equipment.

Epoxy Laminates. Continuous-filament woven glass fabric or paper impregnated with epoxy resin. Glass-fabric grades are designed for use in applications requiring high humidity-resistance, good chemical resistance,



and strength retention at elevated temperatures. Paper grades are used under high-humidity conditions where resistance to acids and alkalis is required. Both grades are characterized by good dielectric strength, low dielectric losses, and high insulation resistance even following severe humidity conditions.

• • •

Recent technical advances in the bonding of various metallic and nonmetallic materials to laminated plastics have opened up new design opportunities. It is now possible to bond virtually any compatible material with a laminated plastic to form a composite which combines the advantages of both. One of the first composite materials was a copper-clad laminate used for printed circuits. More recent composite laminates, usually manufactured to customer specification, include the following: Taylorite® vulcanized fibre-clad, rubber-clad, asbestos-clad, aluminum-clad, beryllium-copper-clad, stainless-steel-clad, magnesium-clad, and silver- and gold-clad. Any one of these materials can be sandwiched between sheets of laminates, too, and can be molded to fit specific requirements.

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We Tried To Do Business with DOD

The Armed Services Procurement Regulation (ASPR) makes it clear that "proprietary data" need not be submitted on advertised bids. But advertised bids have been one of the most fertile areas for troubles and complaints on this nagging problem of proprietary data. The series of articles being published in Aircraft & Missiles are not an attempt to bicker with the government. The editors believe that misunderstandings are corrected only when they are aired. And there are some serious misunderstandings about ASPR IX (2) which need airing.

Following is an edited statement by Richard Hahn, President, Airborne Research & Development Corp. It is a blow by blow account of his encounter with Armed Services Procurement Practices. The original statement was given in testimony before the Select Committee On Small Business, House of Representatives.

Part of the give and take which followed the testimony is also included. It too is edited.

Those involved: Congressman Abraham J. Multer, Chairman, New York; Congressman H. Allen Smith, California; Robert R. Lent, V. P. Riggs Nucleonics Corp.

Hahn . . . "dulled incentive . . . lessened initiative"

Air Force, and Navy, have had trouble with liquid oxygen valves for years. These valves are used on aircraft in the breathing - oxygen system. Main problems are: (1) leakage at —297°F. (2) Unreliable operation from —297°F to over 260°F.

One of the particular problems (about 1955) was the liquid oxygen filler valve. It was giving a great deal of trouble by freezing and leaking. We decided to investigate this problem on our own.

After months of diligent, and sometimes heartbreaking work, we developed the first no-leak liquid-oxygen filler-valve.

The units in use were designed by the Air Force and were being manufactured from Air Force drawings. So, there was no military or procurement specification covering them. We submitted our valve to the Wright Air Development Center, (WADC), who has cognizance of testing this type of equipment. Simultaneously we submitted a similar unit to the Boeing Airplane Co., for possible use on the B-47 aircraft.

Results of the Boeing tests were received first. Exceptional performance requirements were being recorded. WADC authorized Boeing to proceed immediately in using this valve on all B-47 aircraft.

WADC also initiated a military specification, MIL-V-25469, written around the performance, as well as the physical dimensions of our unit. Very shortly thereafter, we were requested by WADC to supply them with one of our drawings on a detail part, constituting the end fitting as well as an integral part of our valve for their evaluation.

Proprietary Right—This drawing was furnished gladly. It carried markings, indicating proprietary rights were owned by our organization. The valve was developed wholly and completely on the resources of Airborne Research & Development Corp., and test articles were submitted at no cost to the Government.

We felt we had proprietary rights. Furthermore, we had no contract stating that we must surrender these rights.

But, WADC shortly issued an Air Force drawing number 56B3695 that if not copied directly, was certainly a Chinese copy of our own drawing No. 4004.

This Air Force drawing is still in effect and is distributed to all manufacturers. It is being produced by many companies. It seems as though, with or without contractual coverage, Air Force exercised the right in data clause regardless of rightful ownership.

Oxygen Filler Valve—Another interesting case involves a valve called the female liquid-oxygen filler-valve for ground handling purposes. A valve originally designed by the Air Force, and in use by the services, was giving considerable trouble with freezing and leakage during the fill operation of the aircraft.

Airborne Research & Develop-

. . . continued on next page

Government picks brains of small R & D organizations; Does ASPR IX make it all legal?

ment Corp. decided to tackle this problem. In three months, a modification was made to the Air Force-designed valve, rendering it literally impossible to freeze, and at the same time incorporating a no-leak check feature.

We submitted test specimens of the valve to WADC at no cost to the Government. After six months, we received a report that the valve had completed its flight-line testing and was completely satisfactory.

WADC Starts R & D—But, rather than write an Air Force specification around this unit, WADC decided to initiate a proposal request for an R & D program to develop a new unit. Quite puzzling, since their own report stated our unit was entirely satisfactory.

However, we responded to this proposal and submitted our quotation. We included a proposal to modify all the present valves in service to the no-leak configuration developed by our organization. Our proposal to modify the Air Force-designed valves would have saved the Air Force many thousands of dollars. They would otherwise have had to spend a great deal on a different type valve and then be faced with a complete retrofit program. In spite of this, they decided to accept another bidder for the initial phase of the R & D contracts.

Still In Evaluation—This transpired about February 1958. The R & D contract was let to another bidder. Subsequently, a valve was delivered to the Air Force for their evaluation. Amazingly, this valve is still in evaluation. At this date, it is undergoing modification by WADC, so that they might obtain the operation and performance characteristics they require. The services are still without a no-leak liquid-oxygen ground-handling valve.

Lox Drain Valve — The next case: In 1958, we saw the need for a valve to be used on aircraft liquid-oxygen converter system for pilot and crew-member breathing. This unit is called a liquid-oxygen drain valve. There was no valve then available to Air Force for this application. We set forth to develop one. We accomplished this task and forwarded our unit to WADC for test and evaluation. This liquid-oxygen drain valve successfully completed all the tests performed by WADC, and a short period later a procurement specification was initiated. The number of this specification is MIL-V-25962. The specification was written, again, around the performance requirements and the physical dimensions of our unit. By the time the Procurement Division was ready to release invitations for bid, other manufacturers had also qualified their unit to this specification. We responded to their invitation for (IFB).

The Rights Clause—On the opening date we found that we were low bidders. Now, this IFB had the rights-in-data clause as covered by General Provision 44. We took no exception to this clause at the time. Our interpretation of the rights-in-data clause was that we could take exception at the time of delivery of the data, if such data was of proprietary nature. After several months of correspondence with the procurement section we found that we were possibly incorrect in this interpretation. During our correspondance, the procurement section had advised us, that if we were going to take exception to the rights-in-data clause, it should have been done prior to the award of the contract. So, we stuck our proverbial "tail" between our legs and proceeded to comply with their interpretation of the contract. The contract was completed on schedule. We felt, at any rate, we had learned what not to do.

Once Burned—Not long after this, we received another invitation for bid No. IFB 33-600-60-43 from WADC, and again, with the rights-in-data clause. So, we said to ourselves, "Ah, Ah! We know how to handle this particular situation." We responded, and in this invitation for bid we took exception to the rights-in-data clause. We stated that the drawings would be furnished, but for the purpose of training, procurement, cataloging, etc. We did not license the Government under this clause as the valve was, again, wholly and completely developed with the initiative and resources of our company.

At the bid opening date, we found that we were the lowest bidder. So, we sat back and patiently awaited the award of the contract. When the award did not come, we initiated action to find out the status of this procurement. Much to our amazement, we found the procurement had been awarded to another company.

We asked the most obvious question, "Why?"

AMC procurement section responded with a letter stating that our proposal was stricken as non-responsive, inasmuch as we had taken exception to the rights-in-data clause.

Primes Join In—I would like to point out a very serious situation which is developing in the aircraft industry. It is basically this: The prime contractors, the major airframe contractors, looking at this rights-in-data situation and seeing it for what it actually means, have included it in their procurement policy. They are doing this regardless of whether it is part of their contract with the services or whether they even have a Government contract requiring the rights-in-data clause.

A specific case is with the Northrop Aircraft Corp. They recently came to our company, requesting a proposal for an oxygen quick disconnect fitting in combination with a "G" suit and ventilation-suit disconnect. Their request for competitive bids included a rights-in-data clause. This item

would become wholly and solely the property of Northrop Aircraft. They would have an exclusive and royalty-free license to manufacture this unit, and to use the drawings for whatever purpose they deemed necessary. This unit, to our knowledge, was to be used in the T-34 aircraft, being proposed to the NATO nations.

Other prime contractors are jumping on the bandwagon and are following suit. Now, with the aircraft industry the way it is, and the contractors requiring all rights to our data, small organizations such as ours, who depend upon doing their own research and development and upon keeping their items protected for themselves, are threatened to the extent of complete extinction. I say this because the prime contractors are very rapidly buying up smaller businesses or even starting new divisions of their own to produce the same items as thousands of small businesses throughout the Nation are now producing. With access to our designs and developments it is quite easy to forecast the future of our Nation's small business industry.

Buy Only Sample Lots—Let's suppose the prime contractor does not include this in his procurement requirements but is still forced by the services to require the subcontractor to comply with general provision 44. What happens to the small businessmen then? Generally, the initial purchases, cover a trivial quantity for production. After the initial R & D is done and prototypes are manufactured, drawings are sent to any number of machine shops across the country for manufacturing of this item. These machine shops need only to follow a drawing, have no engineering, have no investment in research and development, and have no prototype costs. Certainly they can afford, in most cases, to slightly underbid the original designer.

Must Do Something—As small research and development organizations, we must console ourselves that something has got to be done. What can we do? We can do the obvious. We can join organizations who are devoted to fighting for the rights of the small manufacturer.

But what else can we do? Can we fight with the Procurement Divisions? We tried that. My previous statements make it quite evident what the results are when a small manufacturer stands on his own two feet and fights for what he believes is just.

Something is being completely overlooked. The aircraft and missile industry is an industry built largely of small organizations. These organizations are highly technical organizations, highly skilled in their own particular field. What's going to happen when our drawings are sent to any number of organizations who are not specialists in this equipment? Let me assure you, you cannot pick a man's brain completely clean and show everything on a drawing that is in a designer's or manufacturer's thoughts.

Brain Picking—Many, many design details and production techniques never reach the drawing paper, and consequently, a matter of a few thousandths on a drawing, or an overlooked tolerance, can cause a complete failure of a liquid-oxygen valve or liquid-oxygen control unit at cryogenic temperatures. This failure can cost millions of dollars and, more important, probably many American lives.

I know of several specific cases when a small contractor has been beaten to his knees and forced to submit engineering drawings that rightfully belong to him. Out of desperation the drawings have been altered, little details missing, little notes left off, certain tolerances changed.

Many, many things can be done to a drawing that nobody but the manufacturer and the original designer would recognize.

The Commercial Market—We at Airborne Research discussed this possibility and decided against any omissions or alterations of our drawings. We chose another course. We decided to use what was to have been R & D funds to promote as quickly as possible, a commercial division. An item that we manufacture for commercial purposes is sold on the open market in many stores or out of any magazine, and the rights to it remain ours.

Our creativity is also being diverted, along with our funds, in search of new ideas for the commercial field. Possibly in valves. Possibly not. At any rate, what we develop with our own intelligence, with our own efforts, with our sweat and with our hearts, will at least remain ours.

Dulled Incentive — We aren't alone. As more and more manufacturers experience a few of these things, they too are diverting their efforts into something less irritating than doing business in the manner in which we are now forced by procurement regulations.

The Defense Department, by these regulations, have dulled our incentive, have lessened our initiative, and discouraged our creativeness for the military purpose. They have pointed us in the only direction we can now follow.

What Can Be Done?—What can they do if they really desire to have all of the small business squarely and firmly on their great military team?

(1) The Defense Department must strike out these unrealistic and unworkable clauses in the ASPR and NASA regulations, or at least rewrite them to a sensible and workable method of coexistence.

(2) Investigation should be conducted, and a method must be devised to protect the small industries from those who evidently seek its destruction. For, the small businessman's customers are very rapidly becoming his competitors, and with an open pipeline to his creativeness.

(3) Recognize and respect our proprietary rights.

With this action on their part, they will have assured the small businessman that they are concerned with his future, and that they do want him as a member of their team. With this assurance on their part, the small manufacturers across the country will respond, gladly, willingly, tirelessly, and they will pour out their creations for the mili-

. . . continued on next page

Some recommendations for DOD to get small business squarely on defense team

tary use in search for the better mousetrap.

Give us the protection we must have to survive. Then ask, and you will receive.

Mr. Multer. Mr. Hahn, . . . I am sympathetic to your feelings, and probably, if I sat in your seat, would have gotten just as mad as you. . . . But let us try to look at the legal aspects of the problem, so that we . . . can determine if something should be done to remedy this situation. . . .

The first question that occurs to me is when you submitted your valve to Boeing Airplane Co., did you have any contract with them as to the submission?

Mr. Hahn. No, sir; we did not.

Mr. Multer. Was your valve patented?

Mr. Hahn. A patent has never been applied for on this valve.

Mr. Multer. If you do not patent your item, it becomes public property. If you patent it, you have rights given to you by the patent law. . . .

Mr Hahn. Let me add that these cases that we selected for presentation to you were cases not involving patent rights but only involving proprietary rights.

Mr. Multer. That is the point. If they are not patentable, I don't know how you could get the protection. . . . Mr. Lent, I think, wants to add something to it. I will be glad to have your views.

Mr. Lent. You are, of course, correct, Mr. Chairman . . . let me state that it is standard practice for companies like Mr. Hahn's to submit to the military or to a prime contractor an item on a no-cost loan evaluation basis. He does this in good faith.

Mr. Multer. Without contract?

Mr. Lent. Yes, without contract, and the military accepts it, and normally they accept it in good faith. In other words, you have no legal redress . . . but you certainly have a choice—in that you are not forced to do business under this set of ethics.

Mr. Smith. Just a couple of questions to see if I understand this correctly . . . if I understand correctly, the Government is still without a particular female liquid oxygen valve, even though you are in a position to deliver that product to them at this time.

Mr. Hahn. I have been since 1958.

Mr. Smith. They still don't have it?

Mr. Hahn. They do not.

Mr. Smith. With time and the urgency being the essence of our scientific program now, it doesn't make sense to me that this would happen; can you explain why it takes place, or do you have any idea?

Mr. Hahn. The only reasoning I could put to it, is this: Evidently the intent of initiating an R & D program without the completion of our program, would be to insure that the military would own the entire rights to the item. In this way they could put out detailed drawings to industry, to any number of manufacturers or machine shops across the Nation, and get a competitive quotation on the manufacturing of the detailed parts and the final assembly. This is merely a way of circumventing a right that we may have to the proprietary nature of our valve.

Mr. Smith. In the one instance when you came along at a particular time and asked for the rights-in-data clause, it is my understanding that you were told that you should have submitted that prior to the award.

Mr. Hahn. Yes. In this letter from AMC, they stated that inasmuch as no exception was taken to the rights-in-data clause prior to the time of the award, that the contract terms must speak for themselves.

Mr. Smith. In the next instance, when you followed what you learned in that particular instance, and requested it, or decided to rely upon it prior to the award, then you were turned down, and the next higher bid was accepted, because your bid was thrown out as being nonresponsive because you did, at that time, attempt to follow their previous advice. Am I correct?

Mr. Hahn. That's correct, sir.

Mr. Smith. Am I correct that you stated that the Air Force requested the proprietary data to your product, even though they were procuring on advertised bid?

Mr. Hahn. That's correct; yes, sir.

Mr. Smith. You are certain of that?

Mr. Hahn. I am positive of that. I have documents . . . (from AMC).

Mr. Smith. Who signed these letters from AMC?

Mr. Hahn. One of the pieces of correspondence is signed by K. E. Swanson, Acting Chief, Mechanical Equipment Branch, Accessories Division, Directorate of Equipment and Services.

The correspondence which threw out our invitation for bids as nonresponsive, was signed by a colonel, USAF, Columbus E. Tootle, Chief, Accessories Division, Directorate of Equipment and Services.

Mr. Smith. I would like to commend Mr. Hahn for his courage and integrity in coming to us and giving specific instances.

I have not found any specific instances in other hearings which I have read on this subject. I certainly hope that it doesn't in any way hurt your business.

Mr. Hahn. I am sure that it won't.

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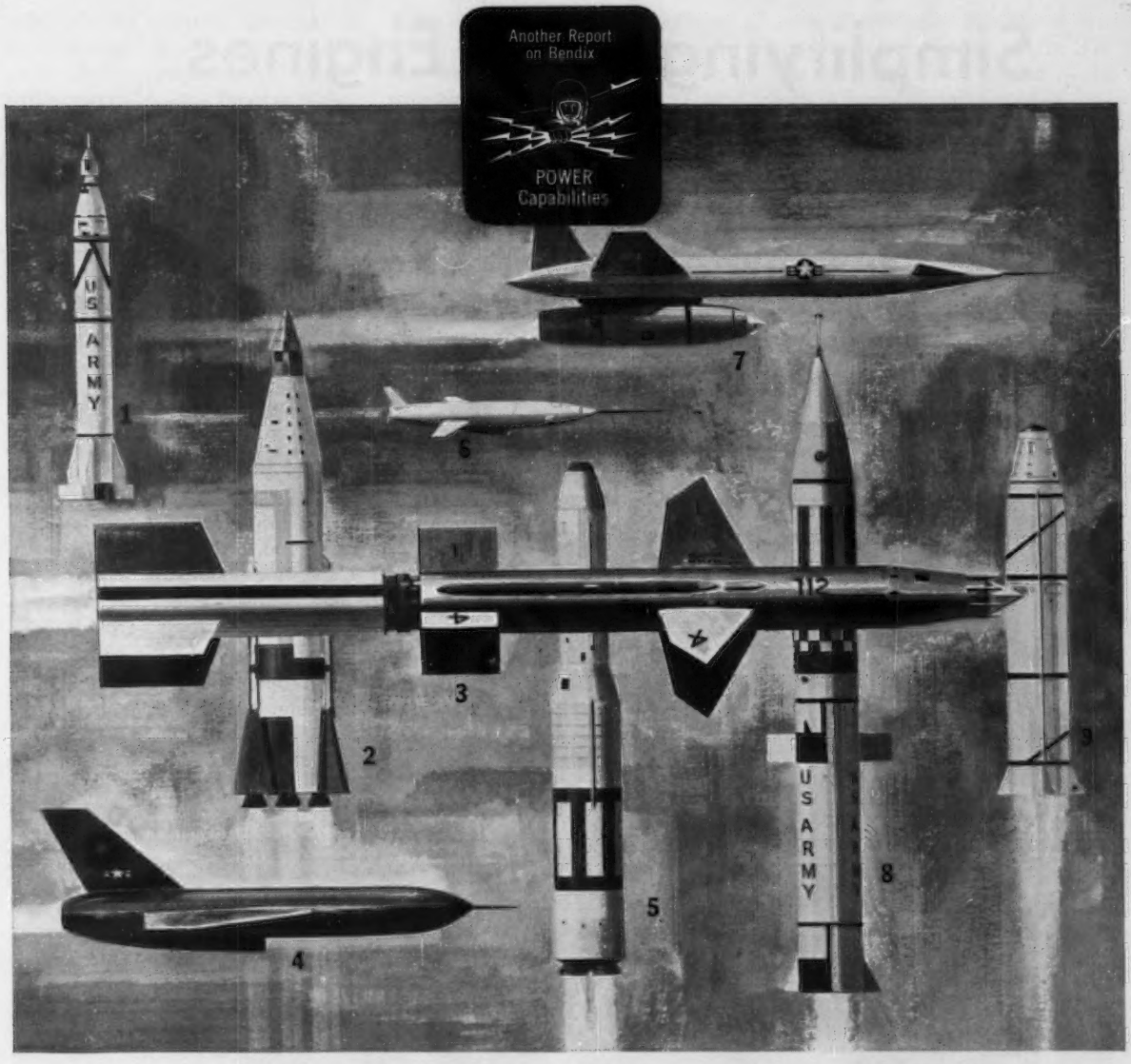

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Simplifying Titan Engines Ups Reliability

Aerojet's design philosophy eliminates engine "service systems," favors "bootstrapped" controls actuated directly by fuel pressure; Malfunction and sequence-monitoring equipment located in launcher rather than on engine or in missile

By Philip Geddes

An Air Force contract was recently awarded to the Aerojet-General Corp. for modifying Titan's first and second-stage engines. These modifications will provide pilot control, and make the rocket powerplants adaptable to the Dyna-Soar program.

Titan engines owe their reliability to the relative simplicity of the design concepts incorporated. Hence, few changes are planned for their use in Dyna-Soar. Principal change involves installation of monitoring circuits so that ground stations, the pilot, or an automatic system will be aware of changing conditions and have control of the engines. Other modifications will allow igniting the second-stage engine before separation, to keep Dyna-Soar vehicle stable during this phase.

From the outset, Aerojet's aim has been to achieve reliability through functionally-simple, self-regulating control systems for Titan's engines. The design staff has sought to eliminate "service sys-

◄ **DYNA-SOAR BOOSTER** will be modified Titan for suborbital phase of test program. Changes will include monitoring circuits for pilot, and ground personnel to control engines. Second stage will be ignited prior to separation, since Dyna-Soar vehicle would be unstable without thrust.

tems" whether electrical, pneumatic, or hydraulic. Service systems are replaced by "bootstrapped" controls; direct actuation force is taken from pressure available in the basic fuel system. Other approaches to simplicity are: direct mechanical coupling of valves instead of using actuators, thermal isolation to avoid heaters, location of malfunction and sequence-monitoring equipment in the launcher rather than on the engine or in the missile.

Principal power-control problems in a rocket engine are:

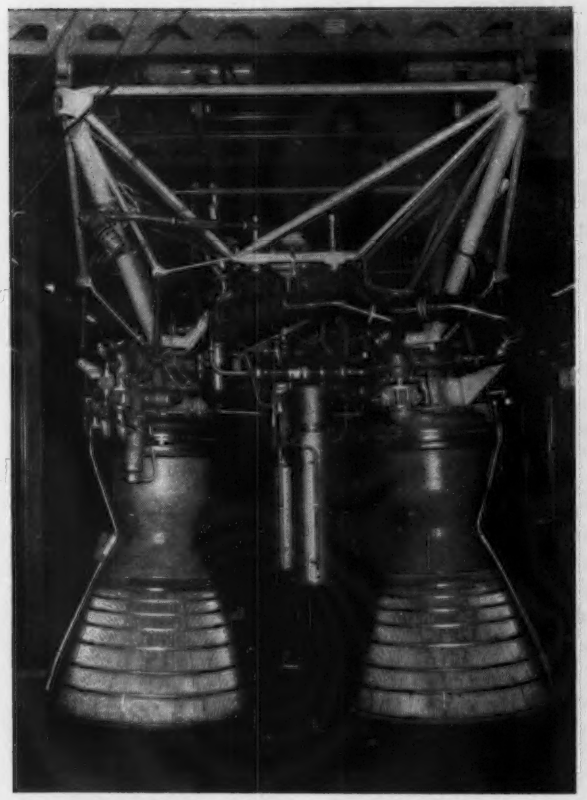
- Propellant ignition
- Regulation during thrust increase to rated thrust
- Malfunction detection during start
- Thrust control
- Mixture ratio

Basic Approach To Design—The optimum system parameters and control parameters for the Titan application were predetermined on paper. From this, a system was developed in which controls could be bench adjusted. Thus, initial firing tests were intended to be indications of acceptable future performance and were not used to empirically-adjust power controls. Analog and digital computer studies were used to determine the following:

- Major component design criteria
- Basic system stability criteria
- Starting transient performance
- Transient hydrodynamics of engine propellant systems
- Performance error bands due to operational tolerances
- Detailed functional design requirements for control components

Mechanical Coupling — Direct mechanical coupling of devices with similar functions is possible in several places on a rocket engine. Direct coupling can be applied to the turbo - pump drive assembly, the thrust-chamber propellant control valves, and the gas generator propellant control valve. Direct coupling offers the advantage of inherent mixture - ration regulation without complicated controls. Most engines built, use a single turbine to drive the fuel and oxidizer pump; the other applications listed above are not universal.

Simplicity Through Elimination—Auxiliary control power systems generally use nitrogen, or helium pressure, regulated hydraulic pressure, or electrical energy for regulation, actuation and sequencing. These systems are extraneous to an engine system. Aerojet set out from the beginning to eliminate auxiliary power systems and the complications inherent in them. In the Titan



FIRST-STAGE ENGINE (at left) of the Air Force's Titan ICBM is seen on production line at Aerojet-General, Sacramento. System develops 300,000 lb thrust in propelling the 110-ton missile at speeds approaching 15,000 mph. Second-stage engine of Titan is shown (at right) mounted in static-test stand. This powerplant, built by Aerojet-General, is claimed as the most powerful and versatile space-started rocket engine ever fired by the free world.

No in-flight shutdown feature in present systems, If engines are safe to start, they are safe to run

first and second stage engines, fuel pressure is used as the source of control power. Actuator size and weight increase in the fuel bootstrapped system, but this is offset by the weight and space saved from the power storage vessels.

Start Sequencing—The start sequence of a rocket engine can be built around either a time base, or a propellant availability criterion. Any start system must use a basic system parameter as a reference index. Fuel-pump discharge pressure is useful as such an index, especially since it eliminates the use of timers with arbitrary time bases. Over a wide range of environmental conditions, timers may be incompatible with engine operation.

A pressure sequencing method based on the pump drive assembly acceleration rate as the "real time" base would, at first, seem to be variable. However, the Titan engine system is designed to utilize that portion of the starting transient where the turbopump torque-to-load (principally inertia) ratio is reproducible from run to run as well as from engine to engine. Such a start sequence is inherently reliable.

Self regulation in a system builds in a fail-safe feature. If the fuel pressure in the Titan falls below the minimum allowable, the engine shuts down. Self regulation about the fuel system makes the engine independent of electrical failure—power can fail, but the engine continues to function.

Engine Controls — Once a rocket engine starts at launching time, it is desirable that the engine run for the full planned duration. There can be no going back. From this, it was concluded that all malfunction-monitoring and sequence controls which could shut down the engine in flight, had no place in the flight system. Accordingly, in the early Titan all first stage sequencing and malfunction devices were located in the launcher. Second-stage engine is designed for an air start. Hence, electrical sequence devices, and a helium start bottle are carried in the missile.

In both first and second stages, engine flight controls are limited to corrective devices rather than shutdown controls. No automatic engine malfunction provisions are made. Command shut down response is made solely for use in the event of guidance system failure and is directed from remote ground command-signal channels.

Included in launcher equipment is a fuel/oxidizer pump turbine overspeed-detection system, combustion chamber burning instability detection devices, and ignition continuity for both stages.

Starting First Stage — Closing the "Fire" switch opens the launcher nitrogen supply to the two fuel/oxidizer turbopump drive assemblies, and at the same time energizes the thrust chamber igniters. As fuel pump discharge pressure rises, the thrust chamber valve pressure sequencing pilot valves open at a precalibrated pressure level. Fuel pressure then opens the thrust chamber valves at an orifice-timed rate.

At a present percentage of thrust chamber valve stroke, a position switch in each valve is opened; the last position switch to open de-energizes the single gas generator pilot valve used for the two gas generators. This pilot valve then opens, supplying fuel pressure to both gas generator valve systems simultaneously to ensure common starting time. Operation of the pilot valve also energizes the gas generator squib igniters.

Gas generator valves open at an orifice-timed rate, initiating combustion in the gas generators and regenerative, or self-fed operation for the complete engine. A position switch on the gas generator valve de-energizes the nitrogen start valve at a discreet percentage of stroke, shutting off nitrogen pressure to the turbopump drive. Gas generator continues to open until the desired thrust chamber pressure is reached. At this point, a thrust control transducer-amplifier becomes operative, and positions the gas generator valves to achieve designed thrust level at each thrust chamber. Engine operation continues at rated thrust ± 3 per cent for the duration of the propellant supply.

First Stage Shutdown—A shut down command signal energizes the gas generator valve pilot valve. Fuel supply to the gas generator valves is shut off and the valves close very rapidly. When the gas generator valves close, pressure switches complete a circuit to the thrust chamber pilot valve override solenoid, and the thrust chamber valves close rapidly. Engine operation is thus terminated abruptly, though in a regulated manner.

Starting Second Stage—Operation of "Fire" switch energizes a helium start valve which supplies gaseous helium to the auxiliary pump drive assembly for the vernier thrust and missile stabilization control system; gas generator igniters are also energized at this time.

Fuel pressure rises in the gas generator feed system and the gas generator valves open at an orificed rate. A position switch in the gas generator valves de-energizes the igniter system. The gas generator valves open wide and supply hot gases to the vernier duct system until the thrust chamber fire signal is received.

Main Thrust-Chamber Operation — At thrust chamber "Fire" switch operation, the pilot valve on the hot-gas diversion valve is energized. The hot-gas diversion valve opens under fuel pressure at an orifice-regulated rate and gas-

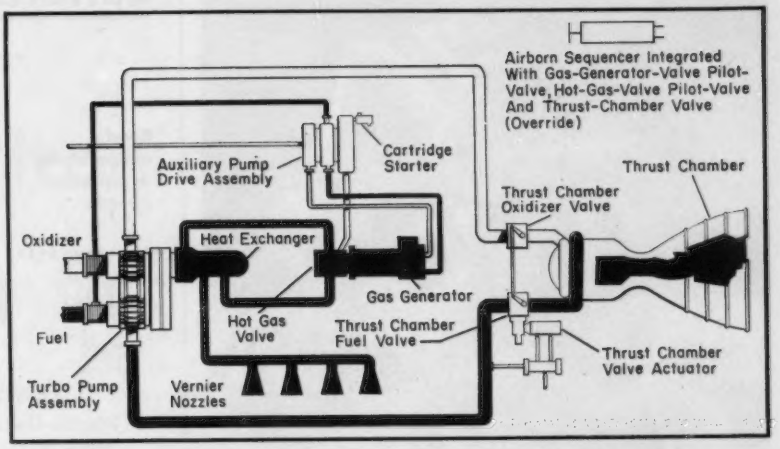
generator gases are diverted to the pump drive assembly. A position switch on this valve energizes the thrust chamber igniters, and the pump drive assembly acceleration begins.

As fuel pump pressures rises the thrust chamber valve pressure sequencing pilot valve opens at a precalibrated pressure level. Fuel pressure then opens the thrust chamber valves at an orifice-calibrated rate. As chamber pressure rises to the rated level, a thrust-control transducer - amplifier becomes operative. This amplifier positions the gas-generator valve to achieve the design thrust level. Engine operation continues at rated thrust for the duration of propellant supply with the vernier system in operation at reduced thrust.

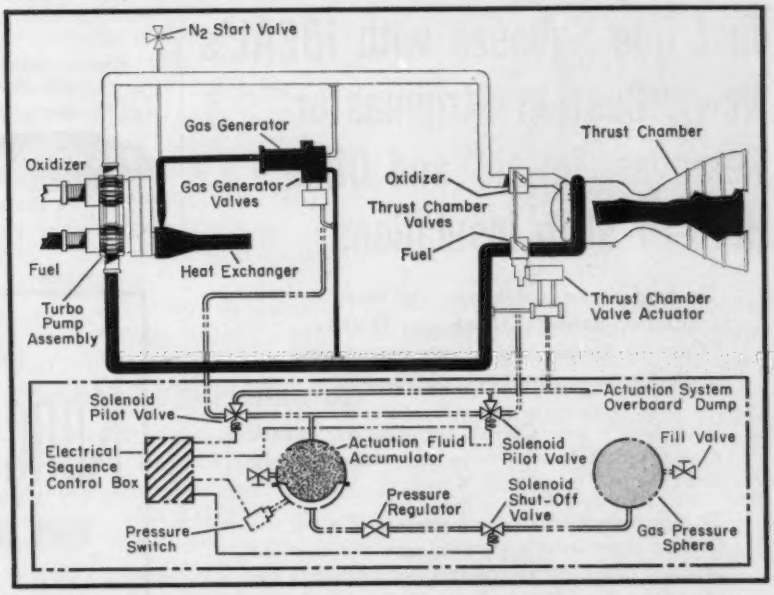
Return To Vernier Operation—When a thrust chamber shutdown signal is received, the hot gas diversion valve pilot valve closes and the hot-gas diversion valve closes rapidly. A position switch then energizes the thrust chamber valve pilot valve override solenoid coil. Rapid, though regulated closure of the thrust chamber valves follows. The gas generator continues operation discharging gas through the vernier system ducting. At vernier shutdown signal, the gas generator valve pilot valve is energized closed. Fuel supply to the gas generator valve actuation system is shut off and the valve closes rapidly shutting off propellants to the gas generator. Engine operation is thus terminated.

Design Philosophy—Basic approach to reliability, in this case, has been through a functionally-integrated system using flow phasing. Advantages, measured in improved reliability, in a functionally-intergrated system come from reduction of components—a reduction in weight does not necessarily follow. The main design problems in the Titan engine came from the interdependence of actuator performance and transient performance of the overall system. This critical phasing of the overall system can be seen in engine start sequencing already described. Developing the optimum system could only be done after studying all the interrelated parameters of subcomponents. Computer technique in determining the range of control of the subcomponents took up a large percentage of an IBM 704 computer's time during development stages.

Original problems were mainly involved in resolving design principles—not in developing materials. More recent studies were materials-oriented to make the engine work with any propellant. Other advanced concepts center on the use of storable propellants.



TYPICAL SECOND-STAGE rocket engine incorporating vernier nozzle system is depicted schematically.



RELATIVE SIMPLICITY of a bootstrapped rocket engine system, presented schematically, results through the elimination of the components shown in phantom lines.

◆

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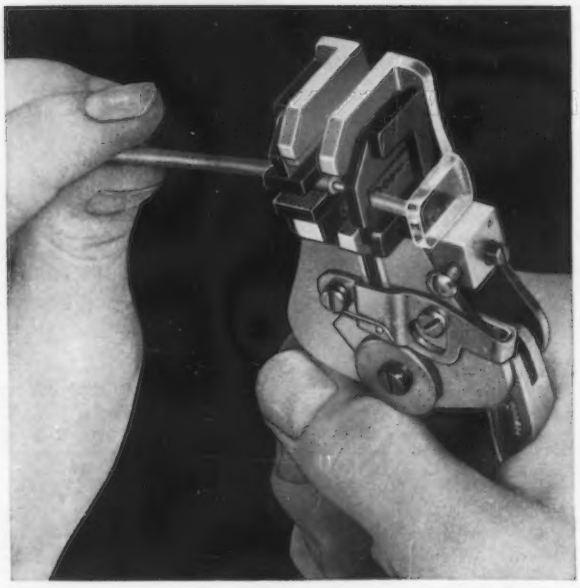

Just One Squeeze with IDEAL's New "Custom Stripmaster" Removes Teflon* and Other Hard-to-Strip Insulations

To help prevent wire nicking and insulation damage, these new IDEAL "Custom Stripmasters" are precision drilled on watchmaker's equipment.

With Ideal's new Custom Stripmasters, a light squeeze on the handles strips any wire completely clean and bare up to a full 7/8 inch.

To help prevent nicking and scraping of wires, the Custom Stripmaster's matched sets of blades are precision drilled on watchmaker's equipment to the exact wire sizes. Counterbored blades ride on cut insulation to prevent scratching of stripped wire. Jaws grip wire firmly to prevent insulation damage. 3 models available. Wire sizes from No. 10 to 30.

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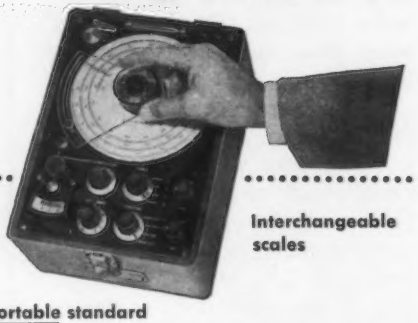
Read temperatures or millivolts directly



Interchangeable scales

A portable standard

The Pyrotest checks recorders, controllers and thermocouples . . . measures temperatures. It is a precision signal source, simulating thermocouple temperatures, for checking other potentiometers. Built-in "run up" permits checking of millivoltmeters.

19 different stock scales will fit one Pyrotest! Scales interchange in seconds. °F. or °C. calibrations for all types of thermocouples supplied. Scales directly read temperatures or millivolts.

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Patented construction provides double sealing action. Excellent for high pressure and high vacuum applications. Pressure ratings 2,000# to 6,000#. Screwed or socket weld ends, for pipe sizes to 2". Send for catalog today.

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Circle 26 on Inquiry Card

New Electronic Products

Tiny X-Band Circulator

Three ounce X-band circulator is intended for microwave systems. The strip line circulator has a minimum isolation of 20 db and a maximum insertion loss of 0.4 db over a 6 per cent band. The package is less than ¾ in. high. Unit has a VSWR of less than 1.4 to 1, handles 10 watts average power and 10 kilowatts peak power. Input impedance is 50 ohms.—Hycon Mfg. Co.

Circle 60 on postcard for more data

Miniature Free Gyros

Two new series of miniature non-floated gyros are available. One is torqueable and one cageable. The cageable is a two-axis miniature-free gyro with either A.C. or D.C. motor. It is available in a choice of three pickoffs: outer gimbal synchro pickoff, potentiometer pickoffs on both axes, or potentiometer pickoff on the inner gimbal and synchro pickoff of the outer gimbal. The other series is also a two-axis miniature free gyro but with synchro pickoffs and torquers on both gimbal axes.—Daystrom Inc.

Circle 61 on postcard for more data

Telemetry Switch

Microminiature telemetering switch provides up to 450 channels in various combinations of circuitry. The 8-oz switch measures 1⅜ in. x 1¾ in. x 2½ in. Exclusive design features and resultant low brush velocity provide operating life expectancy well beyond 1000 hr. The unit enables combinations of circuitry up to a maximum of 5 poles with 90 channels per pole.—Electro Tech. Corp.

Circle 62 on postcard for more data

Solenoid For 1000°F

Special protective coating on hermetically sealed solenoid helps achieve a life rating of 1000 hr at 1000°F. It will withstand up to 1600°F. Plunger travel is 0.020 in., and weight of the unit is 0.28 lb. Conduit is available in two styles: rigid for increased reliability; or, flexible for compactness and installation ease in crowded spaces.—Barber-Colman.

Circle 63 on postcard for more data

Compact Discriminator

Subcarrier discriminator for analog data systems is completely transistorized and designed for high sensitivity. Model GFD-3, and associated equipment, have been selected for the ground data acquisition and analysis systems in "Minuteman" test firings. The unit will operate within specifications at carrier frequencies as high as 300 kc and accomodate intelligence spectra up to 35 kc. Use of the phase-lock loop principle improves sensitivity for detecting weak signals.—Data Control Systems.

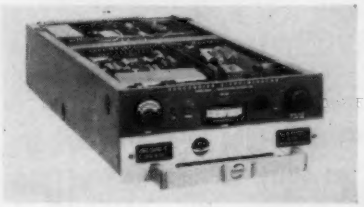

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Image Intensifier

High-vacuum tube intensifies light radiation by electronic means. Tube produces an image of reduced size whose brightness is increased by a factor of 2500 (minimum) for actinic blue input radiation. For input radiation at a color temperature of 2870°K, brightness is increased by 1000. Through use of short-persistence P15 phosphor, brightness decays to 10 per cent in 2.0 microseconds. Input resolution of the tube is 75 line pairs per inch and its threshold for imaging is approximately 10^{-7} foot-candles.—Westinghouse Electronic Tube Div.

Circle 65 on postcard for more data

Flex-Tape Connector

Simple means of terminating, splicing, or tapping unterminated non-prepared flexible conductive tape, has been announced. Electrical continuity, positive gripping, and strain relief are obtained via a single cam adjustment. Multiple barbed contacts are forced through the conductive metal, and firmly implanted into a holding block. Can be used repeatedly without damage.—Digital Sensors Inc.

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. . . *continued on next page*

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CONTROLLED TEMPERATURE SOLDERING IRONS

. . . with advanced features for greater efficiency, longer life.

- **VARIOUS TIP TYPES AVAILABLE.** Made of copper for fast heat transfer and premium iron plating for long life—with built-in Magnastat sensing device.
- **NEW TIP RETAINING NUT MINIMIZES FREEZING.** Seals tip receptacle from flux fumes.
- **NEW RUBBER SHOCK ABSORBER.** Also prevents iron from sliding off bench.
- **NEW, RUGGED, NON-ARCING SNAP SWITCH.** Guarantees continuous, reliable service.
- **PLASTIC HANDLE.** Extra strong—cooler handling.
- **ADVANCED CORD CONNECTION.** Locks cord securely in place, yet permits easy replacement.
- **2 or 3-WIRE CORDS NOW AVAILABLE** for all models. Cords are flexible and light in weight.

Remember, too, Weller Magnastat Soldering Irons automatically maintain the correct soldering temperature—never overheat. They weigh only half as much as uncontrolled irons and give greater heat efficiency with lower wattage. This means more reliable soldering, less down time.

Model TC-552 provides

2 SOLDERING TEMPERATURES

. . . low heat for heat-sensitive soldering . . . higher heat for regular work. Accomplished by interchanging high and low heat tips. 55 watts. **$9.00** list

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MODEL TC-602. 60 watts, for light to medium electrical soldering. **$10.00** list

MODEL TC-1202. 120 watts, for medium to heavy electrical soldering. **$11.50** list

Prices shown are for Magnastat Iron including tip and two wire cord.

Send for NEW Magnastat Soldering Iron literature.

WELLER ELECTRIC CORP. 601 STONE'S CROSSING ROAD EASTON, PA.

New Electronic Products

. . . continued

Heat To Electricity

Nuclear power plant the size of a watermelon will convert heat directly into electricity. Use is for satellites and manned space vehicles. Power plant will generate from 5 to 30 kilowatts of electricity by direct conversion of fission-to-electricity without use of moving parts. Modular design of the plant makes expansion up to 300 kilowatts possible. Radioactive core radiates 3100°F heat into shell of thermionic converter cells.—General Electric.

Circle 67 on postcard for more data

M/S Radiation Counter

Thin slice of silicon forms the tip of new radiation detectors developed to measure the amount of radiation man will meet in outer space. The USAF school of aviation medicine will launch the detectors in simulated space-crew cabins

of high-altitude balloons and on Atlas missile space flights. The device shown will provide a "count" of radiation penetrating a spaceman's cabin and feed the information to a telemeter system for transmission to receiving stations on Earth.—Hughes Aircraft Co.

Circle 68 on postcard for more data

New for Production

Radiant Heater

Portable radiant heater raises metals such as titanium, magnesium, inconal and molybdenum to forming temperatures right at the drop hammer or press. Heater eliminates rejects that result when metal ductility is weakened through heat loss during transfer of blanks from remote ovens to forming facility.

A gold plated, retractible lamp head, holding up to 99 infra-red quartz bulbs, delivers temperatures to 1500°F at the forming block. It also does away with the need to heat soak blanks. — The electric Hotpack Co.

Circle 69 on postcard for more data

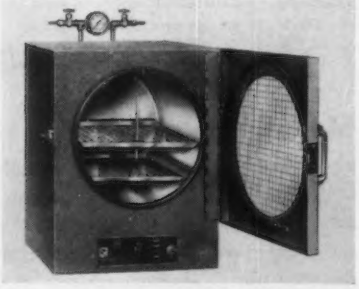
Super Saws

New tungsten carbide blade will cut two to three times faster than present blades and will cut many materials impossible to saw today. The new 2-in. Imperial blade will produce much more accurate cuts because its teeth are ground on all surfaces.—The DoAll Co.

Circle 70 on postcard for more data

Vacuum Oven

Laboratory oven has a temperature range from room to 260°C (500°F) within an 11 in. diam x 12



in. deep stainless steel vacuum chamber. Exclusive feature: an 11-inch diameter safety glass window permitting 100 per cent view of contents.—Labline, Inc.

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Produced by the Technical Film Staff of Turco, manufacturer of the Dy-Chek® inspection process, this 23-minute film visually demonstrates *every* aspect of dye penetrant inspecting from laboratory theory to authentic production-line techniques actually filmed on the spot during mass production inspections.

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FPD PROFESSIONAL EMPLOYMENT NEWS

PUBLISHED BY THE FLIGHT PROPULSION DIVISION OF GENERAL ELECTRIC IN CINCINNATI, OHIO / **NOVEMBER, 1960**

FPD NEWS offers latest information on openings throughout the Division to interested engineers and scientists. Technical information and news relating to current projects will also appear from time to time in this column.

Technical Placement Manager Lists 17 'Most Urgent' Openings

The ever-broadening front of Flight Propulsion Division's power and propulsion programs at Cincinnati, Ohio encompasses turbojets for military and commercial aircraft propulsion, as well as industrial and marine applications, development of advanced liquid rocket engines, electrical space propulsion and nuclear based space power systems, electromechanical control devices and systems.

Engineering opportunities range over all areas of activity, but the 17 positions outlined below are of special interest at this time:

Project Engineer — Nuclear Systems
Develop criteria for systems design, balanced as to performance, weight, etc. Conduct studies in interrelated factors influencing high temperature operation.

Heat Transfer
Formulate and solve problems in heat convection, conduction, and radiation related to development of arc plasma jet rocket engine.

Fluid Dynamics
Conceive and direct projects in fluid dynamics, especially the flow of very high temperature gasses through supersonic nozzles.

Turbine Design
Engineering design, development, and product support programs for turbine components that satisfy project operational requirements.

Compresser Aerodynamics
Guide programs aimed at design, evaluation, and development of jet compressors. Coordinate activities of mechanical design, testing, and other related groups.

Control System Evaluation
Initiate and direct engineering bench evaluation programs to correct system problems, define operating characteristics, and recommend improvements.

Control Systems Design
Establish jet engine control systems requirements and specifications, execute designs and analyses, initiate and direct test programs.

Propulsion System Evaluation
Supervise small group responsible for providing comparative data on installed engine performance, airframe design, and mission performance.

Power Plant Preliminary Design
Conceive and develop complete preliminary designs for new versions of known types of aircraft power plant components.

Performance Analysis
Plan engine and component tests on statistical basis. Issue Performance Test Project Sheets, specifying procedure, instrumentation, accuracy and precision.

Application Engineering
Participate in sale, application, and installation of turbojet engines in aircraft of USAF or foreign governments.

Military Liaison Engineering
Negotiate with military and other government agencies, and provide technical information to gain and maintain support of specified engineering programs.

Metallurgical Engineering
Technical responsibility in metallurgical engineering and allied fields. Initiate and conduct programs in jet engine support.

Sales Engineer — Commercial Engines
Develop and execute promotion and sales of commercial large gas turbine aircraft engines, spare parts, optional equipment and services.

Overhaul Liaison Specialist
Provide complete factory technical support to service shops engaged in overhaul of commercial engines for airline customers.

Turbomachinery Aerodynamics
Innovate and design improved turbomachinery components for space power conversion systems. Formulate and carry out necessary experimental programs.

Engine Systems
Establish reliability programs for evaluation measurements of engine systems. Conduct correction programs aimed at systems optimization.

For further information on these or other positions, write in confidence to Mr. Mark Peters, Dept. 125-MK.

FLIGHT PROPULSION DIVISION

GENERAL ELECTRIC

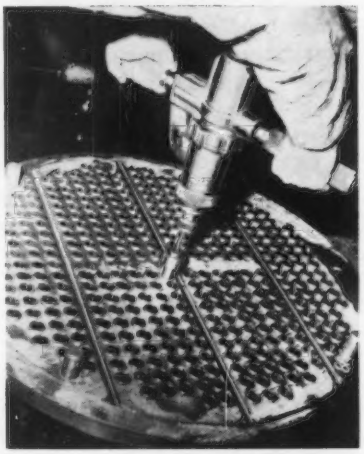
BUILDING 100 CINCINNATI 15, OHIO

New for Production

. . . *continued*

Tube Expansion

Tube expansion control unit provides high accuracy for important tubular subassemblies. This pneumatically-operated instrument



automatically controls tube expansion by accurate measurement of torque. It rolls tubes to uniform accuracy to within 0.001 of an inch, at the rate of 12 tubes per min. The unit automatically stops expansion according to a predetermined setting. Calibrated ring permits settings as low as 0.5 foot pounds and up to 37 foot pounds torque at 90 psi.—Airetool Manufacturing Co.

Circle 72 on postcard for more data

Melting Furnace

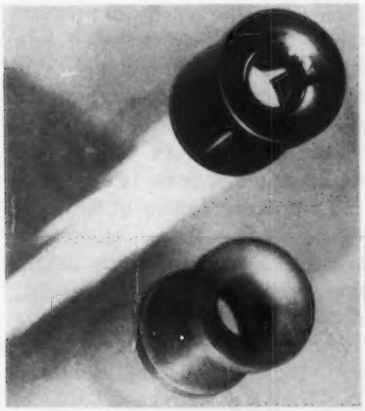
Helium-cooled vacuum arc melting furnace is for recovery of titanium scrap. It is also suited for handling other reactive and refractory metals. Furnace has proven out several unusual design features including its helium gas cooling system replacing the more conventional water cooling.—National Research Corp.

Circle 73 on postcard for more data

New Materials

Super-Graphites

Promising high - temperature rocket materials include a series of high-density super-graphites. Hot working process more akin to



metallurgical than ceramic technology is used to produce them. A recrystallized graphite results with approximately two to three times the high-temperature strength of conventional graphite. Useful at temperatures as high as 5500°F. Polycrystalline nature retains the advantages of machinability and thermal shock resistance, while attaining strengths and densities comparable to pyrolytic graphite.—National Carbon Co.

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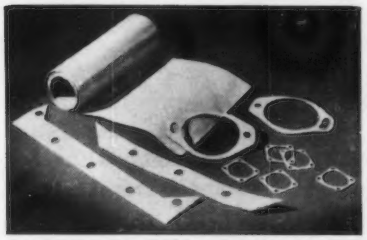
Si-Metal Gasket

COHRlastic Conductive Gasketing is a silicone rubber and met-



al material for high temperature gasketing. It conforms easily to irregular surfaces and is impervious to fluids. Material is available in two types. They are: 30 and 24 mesh aluminum alloy wire cloth impregnated with a 50 durometer silicone rubber to a thickness of 0.016 and 0.020 in. The aluminum wire cloth meets AMS 4182A and the silicone rubber meets AMS 3302B. Will withstand temperatures from –65 to 500°F.—Connecticut Hard Rubber.

Circle 75 on postcard for more data

Stainless Ring-Seal

Metal sealing ring is designed for use on straight thread fittings, where a synthetic rubber O-ring with back-up washer is not acceptable. Seal is a long-sought answer to critical fluid-handling problems. It is designed to work in the standard SAE O-ring fitting boss. Made of type 304 stainless steel, the metal ring handles high temperatures and rubber-attacking fluids as well as high pressures. Shelf stocks are not subject to deterioration. — Parker Hannifin.

Circle 76 on postcard for more data

Photoemissive Material

Photoemissive material maintains a high level of sensitivity after hours of operation at 250°F. Is useful in such devices as imaging and photomultiplier tubes, in which photosurfaces convert radiant energy into electrical energy. Availability permits operation of these photosurfaces at temperatures well above 140°F. Second useful characteristic is that "dark current"—a residual current produced in total darkness—is less than one per cent of that for conventional materials. —Westinghouse.

Circle 77 on postcard for more data

. . . *continued on next page*

HANDLING

CORES & SHELLS
GLASS & CERAMICS
MISSILES & COMPONENTS
NOSE CONES
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Pneuma-Grip®

A new concept in critical Materials Handling

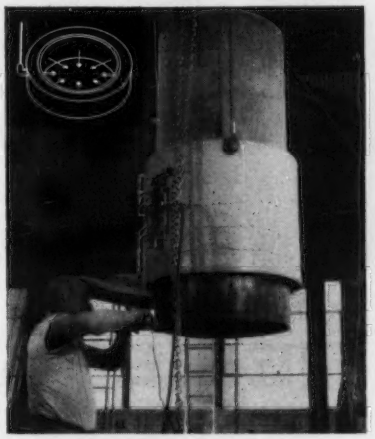

Photo courtesy Frenchtown Porcelain Co.

Controlled air pressure provides a holding method unparalleled in effective critical handling problems. Pneuma-Grip's contact face of air actuated rubber members can grip fragile thin wall or micro smooth surfaced materials regardless of weight or configuration, without adverse effect or change on the structure. Used in conjunction with conventional lift, hoist, handling equipment, Pneuma-Grip is today's answer to critical handling problems. *U.S. Patent No. 2,894,780

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Also manufacturers of Pneuma-Seal for critical sealing problems

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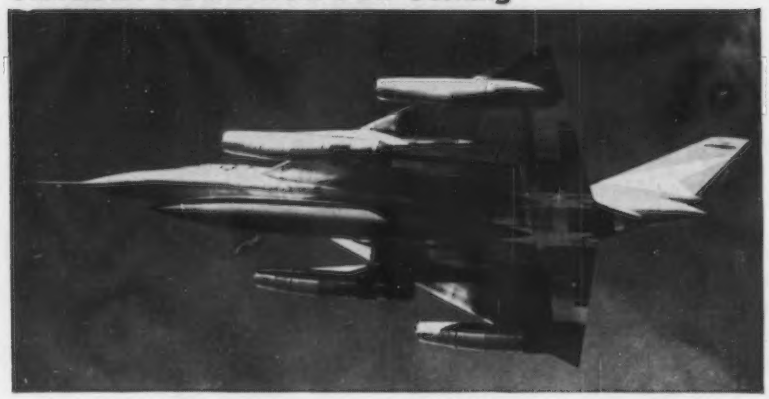
SILICONE NEWS from Dow Corning



Helping a Hustler Hustle

A simple "short" due to insulation failure can ground or make impotent the B-58 Hustler, this nation's present promise of devastating reprisal. That's why Convair engineers specified Silastic®, the Dow Corning silicone rubber, as the insulation for power and control cable.

One moment this super-sonic guardian is streaking through the arctic cold and ozone-containing atmosphere above 50,000 feet . . . minutes later it may be standing in the oven heat of a desert landing strip . . . tough environments for any rubber insulating material — except Silastic.

Write to Dept. 0311 for information

first in silicones **Dow Corning** CORPORATION
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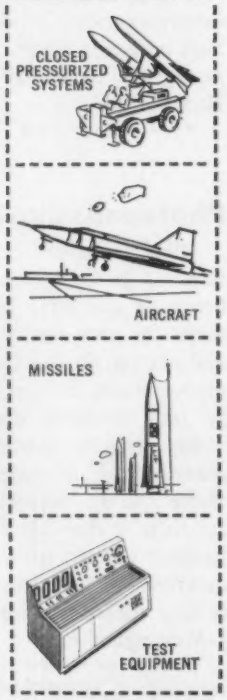
CIRCLE SEAL RELIEF VALVES *for...*

ZERO LEAKAGE AT OPERATING PRESSURES

Where unfailing relief valve performance is an absolute necessity... exacting CIRCLE SEAL 5100 Series valves provide the one perfect answer for critical service requirements. Each valve incorporates the scientific principles and exacting manufacturing methods that have made Circle Seal valves superior examples of the valve maker's art. Each Circle Seal 5100 Series valve offers these advantages: • **Zero Leakage** • **Dead Tight Reseat** • **Minimum Pressure Rise During Opening** • **Excellent Flow Characteristics** • **Tamper-Proof But Adjustable Settings** • **No Chatter Or Squeal** • **Maintenance-Free Service Life.**



CIRCLE SEAL® *precision valves*

Write for free engineering data.

JAMES, POND & CLARK, INC.
2181 East Foothill Blvd., Pasadena, Calif.

Circle 30 on Inquiry Card

New Materials

. . . continued

Titanium Coloring

New process to color titanium has been developed. It coats in brilliant and uniform colors without the use of harmful dyes or paints. Multi-colors can be applied to a single piece of titanium. Process gives two basic benefits to products. One is resistance to chemical corrosion; the other is the ability to remain color-fast to temperatures to 600°F and legible after extended exposure to 1000°F. It is suitable for high temperature name plates and the color coding of fasteners, valves, nuclear reactor components as well as chemical pipes and fittings.—Hi-Shear.

Circle 78 on postcard for more data

X-Shaped Seal

All metal seal called "Bar-X-," withstands temperatures from –450° to 1200°F and peak pressures of 40,000 psi. Claimed as a major breakthrough in the art of seal design the seal can be used for the most demanding seal application.

A cross section resembles an "X" to provide elastic deflections and high sealing forces. Seal has zero leakage from room temperature to 1000°F with dry nitrogen at 1000 psi.—Wiggins.

Circle 79 on postcard for more data

New Parts and Components

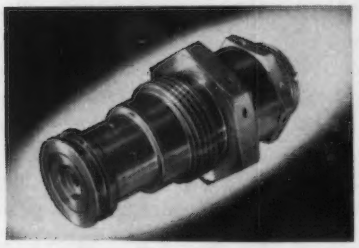
Airstream Direction

System senses direction of local airflow to an accuracy of better than 0.1 deg, at speeds over 90 kt, with a time constant of 0.007 sec at Mach 0.15, and 0.014 sec at Mach 3. It may be used to detect angle of attack or side-slip; it gives a continuous reading with no flutter or overshoot from 60 kt to Mach 4.5. In sensing of angle of attack, once calibrated, the system may be used as the primary aid in preference to airspeed indicator in all phases of flight. Applications include Royal Navy Scimitars, Sea Vixens and Blackburn NA. 39 aircraft.—Ferranti Ltd.

Circle 80 on postcard for more data

Flow Regulator

Cartridge flow regulator maintains constant flow to the system when the pump output or the upstream or downstream pressures vary. Used in a single body or a



multi-valve manifold, the valve is available in a wide range of 0.1 gpm to 6.5 gpm flows. It features an external adjusting screw that permits field adjustments of ±10 per cent for flows 0.1 to 1.5 gpm, and ±5 per cent for flows 1.5 to 6.5 gpm. Built for 0 to 2000 psi operating pressure, it has a pressure drop of 25 psi at high flows and 50 psi at low flows. Features hard-coated aluminum and passivated stainless steel parts. Weighs 4 4oz. —Fluid Regulators Corp.

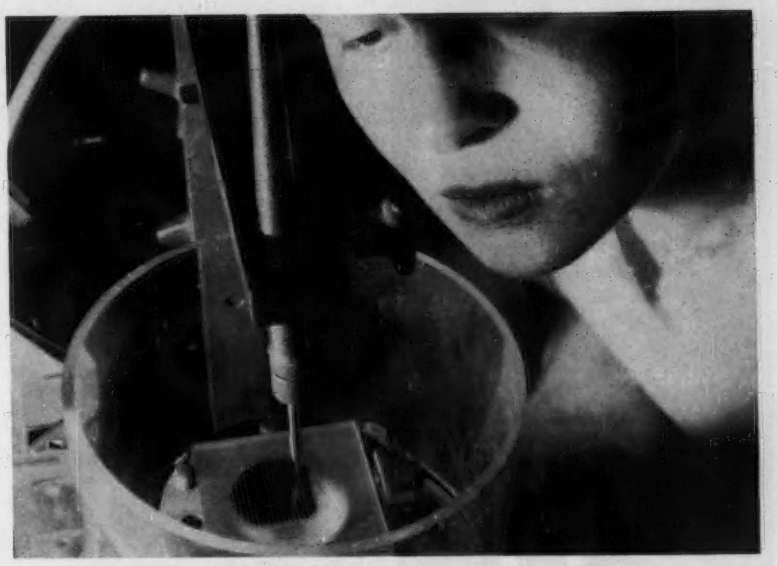
Circle 81 on postcard for more data

. . . continued on next page

Another "impossible" job done by the Airbrasive®...

...cutting semiconductors

abrading • cutting • deburring • stripping • drilling • cleaning • scribing



Hughes cuts fancy figures in silicon. Reports "Airbrasive is the only tool capable of handling the process!"

Hughes Aircraft uses the Industrial Airbrasive linked to a pantograph to cut intricate patterns and shapes in semiconductor wafers. And what's more they are doing it accurately and with *complete safety to the fragile part.*

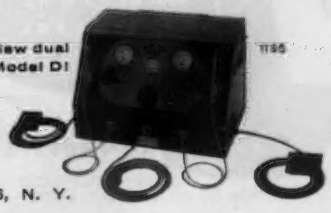
The secret of this unique tool is a superfine jet of abrasive particles and dry gas, directed through a carbide nozzle. The resulting cutting action in hard brittle materials is cool, rapid, precise, and completely shockless.

The Airbrasive is being used to solve hundreds of seemingly impossible jobs . . . precision deburring . . . to remove surface deposits . . . form and adjust microminiaturized circuits . . . cut glass, germanium, tungsten, ferrites, and others.

Low in cost too. For under $1,000.00 you can set up your own Airbrasive cutting unit!

Send us samples of your "impossible" jobs and we will test them for you at no cost.

SEND FOR BULLETIN 6006 . . . complete information.



S. S. White

S. S. White Industrial Division
Dept. 18A, 10 East 40th Street, New York 16, N. Y.

Circle 32 on Inquiry Card

the sky's the limit!

Into orbit goes a product of years of exhaustive research.

When the count down occurs, the critical product must meet the demands.

For years Wall Tube's depth of experience has met the demands of even the most exacting tests. Seamless and welded stainless steel tubing of the highest quality is the Wall Tube standard.

Our representatives are anxious to demonstrate the reliable Wall tubing line. Investigate this vital new source today!

RANGE OF MANUFACTURE

Stainless Steel — Welded and Cold Drawn — 1/8" OD to 3 32" OD, .083 to .088 walls. Seamless — 1/8" OD to 3 32" OD, .049" to .008" walls. Nickel and nickel alloy — seamless — 1/8" OD to 3 32" OD, .049" to .008" walls.

WALL TUBE AND METAL PRODUCTS CO.

NEWPORT, TENNESSEE

Circle 33 on Inquiry Card

New Parts and Components

. . . *continued*

Vibration Mounts

Model K740-4, all-stainless steel mounting system consists of two main trunnion engine mounts and

one forward steady support mount combined for vibration isolation and noise attenuation. Use of Met-L-Flex resilient cushions permits service from —60°F to 350°F. Cushions also withstand exposure to oil, moisture, dust, ozone and other adverse factors in the environment. Mount natural frequency is 25 cps under minimum load and thrust and 35 cps under maximum load and thrust. Transmissibility is less than 3½.—Robinson Technical Products.

Circle 82 on postcard for more data

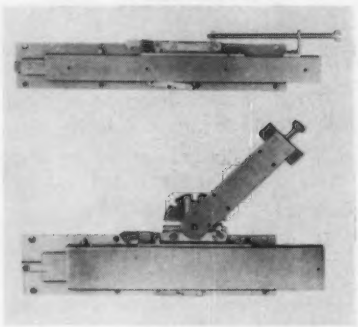
Electronics Cooler

Peltier cooling module, utilizing only partial capability, dissipates 65.3 w of heat to ambient air at 140°F, at sea level; temperatures are maintained below 110°F. Unit requires 20 amps, 5.5 vdc power input of 110 w for cooling. It uses 64 thermoelectric couples to form a cooling plate.—AiResearch.

Circle 83 on postcard for more data

Chassis Slides

Positive Slide Lok eliminates the problem of locks releasing under shock and vibration testing. It can

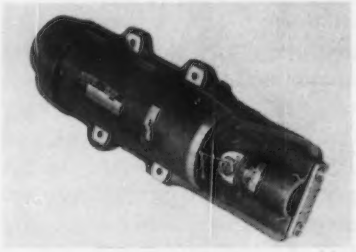


only be released manually, by a button which is an integral part of the Lok. Many combinations of locking and pivoting mechanisms are available. Slides are made of high tensile, heat-treated, anodized aluminum with ball spacers, ball bearings and stop pins of passivated stainless steel. Weight capacities range from 50 to 500 lb per pair; lengths from 10 to 68 in.—Grand Sliding Mechanisms.

Circle 84 on postcard for more data

Auxiliary Power Unit

Manifold-type APU drives the main hydraulic system in the 1st and 2nd stages of the Polaris. It operates on 28 vdc batteries at 11,000 to 20,000 rpm. Pump section operates on 5606 fluid up to 275°F. A thick silicone coating surrounds entire package and permits mounting within inches of



rocket blast. Silicone is applied in an "unaged" condition, and as temperature rises, silicone is aged. Thus the coating acts as a protective "heat sink."—Vickers.

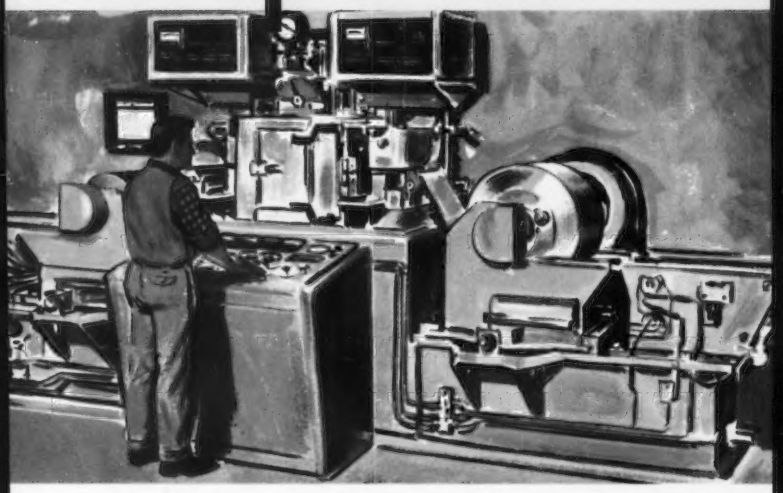
Circle 85 on postcard for more data

Circle 34 on Inquiry Card——→

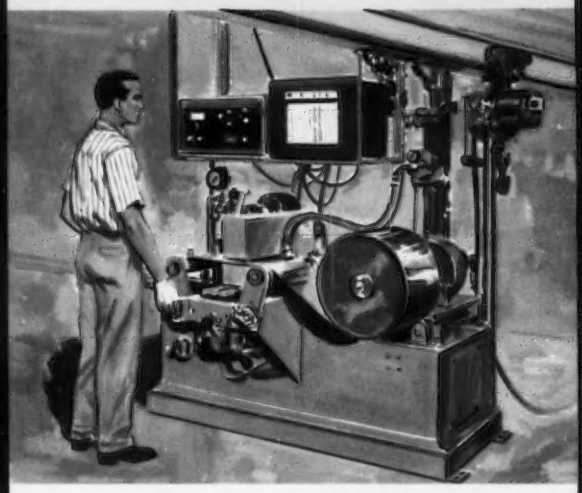
Specialized Facilities for

STAINLESS STEEL

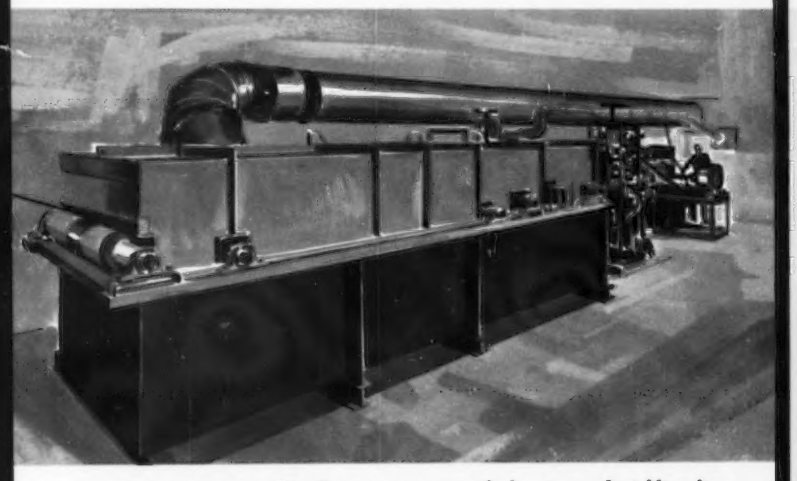
Custom and Conversion Rolling



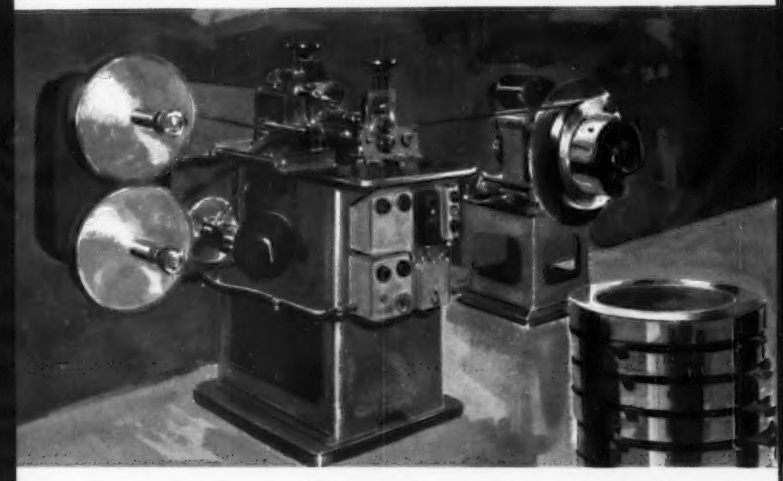
12½" SENDZIMIR MILL • Our 12½ inch "Z" mill rolls all metals to thicknesses as thin as .0003".



INSPECTION • Inspection, both visual and beta gauge, with continuous recording guarantees close tolerance satisfaction.



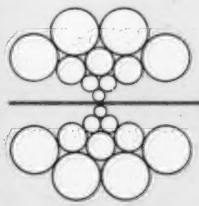
ACID CLEANING • The first continuous acid cleaning and pickling line of its kind in the country.



SLITTING • Precision slitting entirely separate from our facilities for standard production.

Reliable Rodney says:

"The first super-thin, extra wide (24") precision rolling of the following alloys was done right here at Rodney: high nickel, uranium, titanium, stainless, columbium. A combination of specialized equipment unequalled in the industry makes Rodney a tailor-made plant for conversion. We have these additional new facilities to give you the finest quality and service in processing super-thin, stainless steel and special alloys. Let us convert your metals and alloys to the exact specifications you require."



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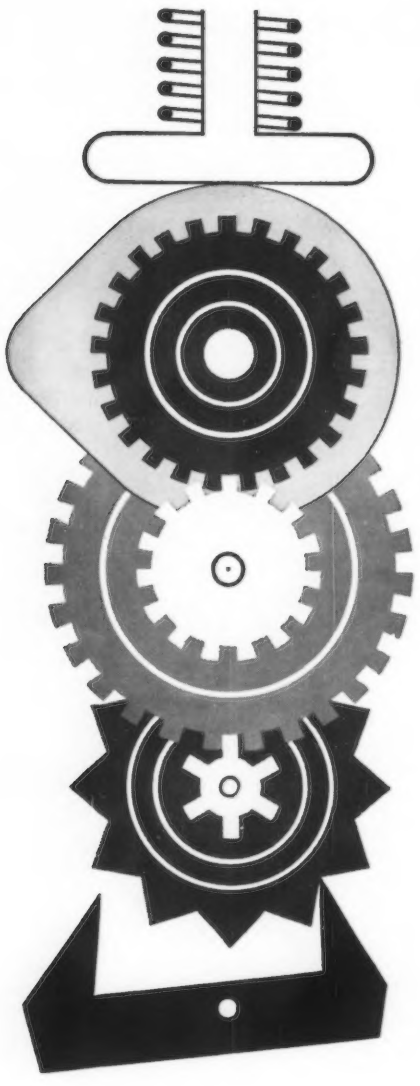

Bulova run-away escapements

Bulova's mastery of the measurement of time holds practical solutions to some of the growing challenges in defense and industry. One case in point is the Bulova run-away escapement: a simple, rugged and relatively inexpensive device for metering short periods of time. Currently used in accelerometers and velocity indicators, these mechanisms have wide areas of application yet to be explored.

The artist's conception above depicts a run-away escapement designed for governing the speed of a cam system driven by a mainspring. The torque transmitted through the gear train rotates the scape wheel which, in turn, oscillates the pallet. The starting and stopping of the pallet as it oscillates acts as an inertia brake or governor on the whole system.

The idealized equation defining the motion of the pallet is simply

$$T_p = I_p \frac{d^2\theta}{dt^2}$$

The initial conditions at $t=0$ are $\theta=0$ and $d\theta/dt=0$. Integrating *Eq (1)* twice and applying the initial conditions results in

$$t_1 = \sqrt{\frac{2I_{p1}\theta_1}{T_{p1}}}$$

where θ_1 and t_1 denote the half-cycle amplitude and half-cycle period respectively, and the total pallet amplitude is $\theta_1 + \theta_2 = 2\pi/n$.

In this example, the escapement controls the action of a cam-follower mechanism. The same principle can be adapted to many other applications such as: a timer for closing an electric circuit: a velocity indicating device used in computers for integrating acceleration-time functions.

Bulova skills come from close association with the involved problems in developing, designing and producing timing mechanisms which fully meet the stringent specifications of the military and industry.

BULOVA

Bulova Research & Development Laboratories, Inc.
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MOON STEEL
Because stainless steel has helped to bring man's conquest of the heavens ever nearer, it has rightfully earned a new space-age name —MOON STEEL.
Since 1955, Washington Steel has been the exclusive supplier of light gage stainless steel sheet for the outer covering of the Atlas missile. The reason is simple: Washington Steel pioneered in the art of rolling stainless steel to uniform gages and has been able to meet the exacting specifications set up by space engineers for this momentous undertaking.
This is why MicroRold* stainless is truly out of this world!
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Worth Asking For

Spiralloy

General properties, uses, design considerations of Spiralloy, used in Minuteman third stage and other continuous filament-wound, resin-bonded glass fiber structures.—*Hercules Powder Co.*

Circle 86 on postcard for more data

High Purity Metals

Booklet shows fabrication, application of Space Age metals.—*Lunex Co.*

Circle 87 on postcard for more data

Sergeant

Brochure illustrates, describes Sergeant production, support. —*Sperry Utah Engineering Laboratory.*

Circle 88 on postcard for more data

Honeycomb R & D

Brochure on R & D facilities.—*Hexcel Products Inc.*

Circle 89 on postcard for more data

Space Navigation

Compilation of technical articles on "Space Anthology" and "Doppler Navigation." — *GPL Div., General Precision, Inc.*

Circle 90 on postcard for more data

Chromallizing

Effects of chromallizing superalloy gas turbine vanes detailed in Bulletin 501.—*Chromalloy Corp.*

Circle 91 on postcard for more data

Power Supply

Bulletin TT-160 presents performance and physical characteristics of 3½" regulated d-c power supplies rated at 2 to 35 volts, zero to 1, 2, or 4 amps.—*Dynamic Controls Co.*

Circle 92 on postcard for more data

Explosion Protection

Brochure on firm's explosion protection systems.—*Fenwal Inc.*

Circle 93 on postcard for more data

MISSILES
BREATHE TOO
YOU KNOW...

...that's why major missile manufacturers specify MIDGET LOUVERS

"REGULAR" —with screen and all-weather deflector.

"LD"—screened for interior and protected exterior locations.

In seven sizes to meet your needs — one inch through six inches. Available in chrome, aluminum and copper rustproof finish . . . installs easily and quickly. Write for our catalogue sheet.

MIDGET LOUVER COMPANY
6 Wall Street • Norwalk, Conn.

Ferrous Forgings

28-page booklet describes facilities for producing drop, upset and press forgings.—*American Brake Shoe Co.*

Circle 94 on postcard for more data

Grinding Tools

36-page catalog has details on portable, precision grinding tools and small hole drilling equipment.—*The Dumore Co.*

Circle 95 on postcard for more data

Film

Bulletin on type 140 negative film for photographing missiles, aircraft against a sky background.—*Du Pont.*

Circle 96 on postcard for more data

Microwave Catalog

Catalog describes line of power supplies.—*Orion Electronic Corp.*

Circle 97 on postcard for more data

Heat Processing

Bulletin describes machines for heat treating, selective hardening, brazing and soldering, annealing and other processes for heating metals. —*Selas Corp. of America.*

Circle 98 on postcard for more data

Vibration Testing

Brochure describes line of products to excite, measure and control vibration.—*MB Electronics.*

Circle 99 on postcard for more data

Heat Fixtures

Catalog sheet illustrates parts-holding fixtures for four principal types of heat treating furnaces.—*Wiretex Manufacturing Co.*

Circle 100 on postcard for more data

RTV

Bulletin illustrates aerospace applications of firm's Room Temperature Silicone Rubber.—*Silicone Products Dept., General Electric Co.*

Circle 101 on postcard for more data

Temp Conversion

Temperature-conversion chart converts between C, F, R, and K over range from absolute zero to 6500 deg. C.—*Rosemount Engineering Co.*

Circle 102 on postcard for more data

Blueprint File

Brochure on wall-type file allowing blueprints, other large sheet materials, to hang flat.—*Lewbill Industries.*

Circle 103 on postcard for more data

Glasses

Booket details properties of 32 commercial glasses. — *Corning Glass Works.*

Circle 104 on postcard for more data

Instrument Brochure

Specs on 13 new instruments.—*Instrument Div., Bourns Inc.*

Circle 105 on postcard for more data

Silicones

Reference describes applications for silicones in military and commercial aircraft, missiles, and ground support equipment. — *Dow Corning Corp.*

Circle 106 on postcard for more data

LIGHT IN WEIGHT

BUT **HEAVY ON PERFORMANCE**

miniature instrumentation designed for space vehicle and airborne applications is little in size but big, really big in performance. Reliability is inherent in the design and rugged construction.

MICRO MINIATURE SOLID STATE DC VOLTAGE REGULATOR MODEL 8-3

FEATURES:
- Output Voltage Adjustable by Customer
- Minute Size — 1¼" x 1¼" x 1⅜" — 2.1 cu. in. Lightweight — 65 grams
- Regulation — Better than 0.4% at Rated Load
- Completely Encapsulated
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MINIATURE ADJUSTABLE SEQUENCE TIMER MODEL 4-23

FEATURES:
- Small and Compact — 1½" x 2½" x 3" — Lightweight — 11 oz.
- Accurate — Better than 0.3%, Self-contained Voltage Regulation
- Adjustable Time Span — 1 sec. to 45 min.
- Multiple Switch Closures
- Low Current Drain — less than 70 milliamps
- Modular Construction for up to 100 Switches with Optional Remote or Manual Reset Feature

MINIATURE TIME DELAY INTEGRATING ACCELERATION SWITCH

FEATURES:
- Temperature Compensated, −65° to +160°F.
- Fluid Damped
- High Accuracy
- Available for any Time Delay from milliseconds to seconds with Range from 1 to 150 G's
- Designed for Arming, Destruct, and Safety Circuits, etc.
- Small, Compact — 1½" high x 1" diam. Weight — 50 grams

All are environmentally tested to surpass MIL-E-5272C for Vibration, Shock and Acceleration.

These are typical of modular type, off-the-shelf catalog items in the line of space instrumentation.

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West Coast Office
8530 Wilshire Blvd., Beverly Hills, California

Circle 38 on Inquiry Card

Gamma Spectrometer

Brochure 704 describes improved spectrometer system for identifying, tracing and labeling gamma-emitting radioisotopes. — *Nuclear Measurements Corp.*

Circle 107 on postcard for more data

Spot Welding

Brochure describes equipment and procedures for spot welding hardenable steels. — *The Taylor Winfield Corp.*

Circle 108 on postcard for more data

Contract Research

Illustrated statements on contract research for industry.—*Battelle Memorial Institute.*

Circle 109 on postcard for more data

Scale Models

Folder on applications of scale models in industry.—*Knight Models, Inc.*

Circle 110 on postcard for more data

Magnetic Components

Catalog gives basic line of coils, filters, amplifiers. — *Communication Accessories Co.*

Circle 111 on postcard for more data

Super Alloys

New edition of "Super Alloy Tubing" selections guide.—*Superior Tube Co.*

Circle 112 on postcard for more data

Silver Alloy Brazing

Bulletin on self-study silver brazing training course.—*Handy & Harman.*

Circle 113 on postcard for more data

Corrosion Computer

Computer operates in slide from; shows how various metals react with 141 chemical agents.—*The H. M. Harper Co.*

Circle 114 on postcard for more data

Data Recorders

Brochure on photographic data recorders for missile and aircraft evaluations.—*Vought Camera Co.*

Circle 115 on postcard for more data

Super 26

Photo progress report on Lockheed Super 26, executive transport which is modified B-26. — *Lockheed Aircraft Service.*

Circle 116 on postcard for more data

Ground Support

Brochure, "Ground Support Equipment for Electronic Systems." —*Melpar Inc.*

Circle 117 on postcard for more data

Formica

1961 edition of Formica Designer's Fact Book.—*Formica Corp.*

Circle 118 on postcard for more data

CJ 610

Bulletin GED-4208A on CJ 610 turbojet.—*General Electric Co.*

Circle 119 on postcard for more data

where precision counts . . .

count on Airetool grinders for fine metal finishing

In aircraft and missile development, where success hinges on extreme accuracy, Airetool grinders meet and exceed most requirements for precision grinding and fine finishing of dies and metals. Rugged, air-driven motors supply power to spare; strong, lightweight construction stands up under constant use; perfect balance makes handling easy.

And, for important tubular sub-assemblies, where tubes must be expanded into another assembly, check the speed and accuracy of AIRETROL tube expansion control. One man rolls up to 12 tubes a minute to ± .001" accuracy and produces strong, uniformly tight joints every time.

Prove Airetool capabilities for yourself; write us about our no-obligation, in-plant demonstration of all Airetool pneumatic production tools and equipment.

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CANADIAN PLANT: Brantford, Ontario
EUROPEAN PLANT: Vlaardingen, The Netherlands

Circle 39 on Inquiry Card

Men on the Move

DAVID F. SHAW, appointed general manager of General Electric's Aircraft Nuclear Propulsion Dept.

ALLEN F. DONOVAN, appointed senior vice president, technical, of the Aerospace Corp., JACK H. IRVING, named vice president for systems research and planning; WILLIAM W. DRAKE JR., named vice president for administration; NAJEEB E. HALABY, named secretary treasurer; EDWARD J. BARLOW, appointed vice president of the Engineering Div.; DR. CHALMERS W. SHERWIN, named vice president and general manager of the Laboratories Div.

DR. EDWIN MORRIS HUDSON has joined the engineering staff of the Defense and Industrial Div., Otis Elevator Co.

DR. CONRAD L. LONGMIRE, appointed a member of the staff of the Avco-Everett Research Laboratory.

EDWARD J. COTTRELL, appointed manager of information services for the Orlando Div. of The Martin Co.

CAPT. FRANK W. TAYLOR, USN (Ret.), appointed assistant to the engineering vice president of Consolidated Systems Corp.

JAMES W. JONES, appointed vice president in charge of sales, Holex Inc., JACK W. BOOTH, named material manager.

H. O. "PAT" BALES, promoted to vice president and also named to the board of directors at Navan Products Inc.

BERNARD W. MENKE, appointed manager of administration of American Machine & Foundry Company's Government Products Group.

WILLIAM E. DIEFENDERFER, appointed assistant general manager of Hamilton Standard Div., United Aircraft Corp.

ROBERT B. ABBEY, appointed senior product engineer at the Rialto rocket motor plant of B. F. Goodrich Aviation Products. HARRY H. DAVIS, appointed western manager-rocket motors.

G. T. SMITH, appointed sales manager of the Aero-Engine Div., Bristol Siddely.

JOHN MANNIELLO, appointed director of marketing of CBS Laboratories.

J. CURTIS COUNTS, appointed assistant director of industrial relations for Douglas Aircraft Co.

JAMES V. CRAWFORD, promoted to assistant manager of the Los Angeles div., AiResearch Manufacturing Co.

ANTHONY SOLAZZO and ALLEN SHEETS have joined the R & D staff of National Beryllia Corp.

W. E. "WALT" LAVELLE, appointed manager of manufacturing for Beech Aircraft Corporation's Boulder, Colo. Div.

ROBERT L. SCHWERIN, appointed quality control manager of the Paramus, N. J. plant of the ACF Industries electronics division.

ARTHUR F. DICKERSON, named project planning manager for the advanced product planning operation of general Electric's Electronic Components Div.

JAMES EBERHARDT, named plant manager for Western Operations, CTL Div., Studebaker-Packard Corp.

KARL R. WUENSCH, named manager of a new plant to be built in Raleigh, N. C. by Corning Electronic Components.

EDWARD J. GREENBOLT, named sales manager for the equipment development and manufacturing operations at Philco's Lansdale Div.

W. E. LaVelle
Beech Aircraft

James Eberhardt
CTL

Karl R. Wuensch
Corning Electronic Components

3 ELEMENT

SPEED SENSITIVE

SWITCHES

DIMENSIONS . . . 2⅛" Dia. x 6" Long

WEIGHT . . . . . 1¾ lbs.

Synchro-Start Model GA-3 speed sensitive switches are suitable for installation on AND20005 aircraft tachometer drive pad.

•

These units are adjustable while running, splash proof, and have a flexible drive shaft to compensate for mounting misalignment. They can be supplied to open or close 3 separate circuits at any speeds between 350 and 6,000 RPM in the standard governor. Special speeds either above or below the standard model must be referred to our Engineering Department.

Other governors with 1 and 2 switches are available with a variation of mountings for tachometer cable and SAE coupling drives.

SYNCHRO-START PRODUCTS, INC.

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Manufacturers of

AUTOMATIC ENGINE CONTROLS • SPECIAL CONTROL PANELS
SAFETY ALARM SETS • D.C. SOLENOIDS • HEAVY DUTY RELAYS

Circle 40 on Inquiry Card

Industry Notes

The Courier Capsule

Courier 1B, forerunner of Project Advent 24-hour "stationary" communications satellites, is primarily a "delayed repeater" for high-speed transmission of microwave teleprinter messages. It records messages from a ground station for later retransmission to another ground station.

Most of the techniques in use are those of an operational system; however, ground stations will try out facets of a more efficient still-evolving military communication procedure. They will use Courier for some "real time" transmission in which a message is instantly retransmitted as it comes to the satellite.

Developed and fabricated by the Western Development Laboratories of Philco Corporation's Government and Industrial Div., Courier 1B is a 51-inch-diam. sphere weighing about 500 lb. About 300 lb. of this is instrumentation. Spare equipment takes nearly half the allowable weight and space. Because of this redundancy, Courier 1B is regarded as the most "sophisticated" U. S. payload yet produced.

Earth-bound equipment which "gives voice" to Courier was developed by International Telephone and Telegraph Corp. Laboratories, Nutley, N. J. Equipment can handle 340,000 words per satellite pass. VHF band is used for signal acquisition and telemetry functions. UHF frequencies were selected for the communication channel.

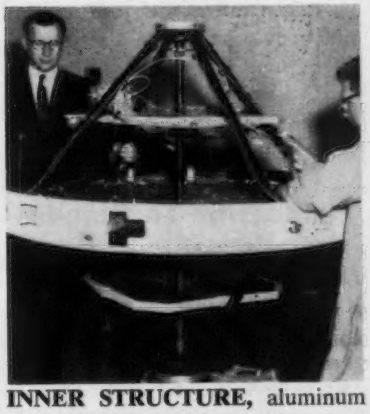
Satellite alerts station of its approach by beaming a signal from a small transmitter. A receiver coupled to a tracking antenna at the ground base automatically locks on the warning beacon. Once acquired by one of the two ground stations (one in Fort Monmouth, N. J.; the other in Salinas, Puerto Rico), Courier may be commanded to transmit one message while it records another.

Ground antennas used in the line-of-sight transmission are 28-ft. diam. steel mesh parabolas designed and built by Radiation Inc. Satellite contains a "command decoder" handling coded signals and commands.

Details of payload:

- Outer shell consists of two lightweight hemispheres, joined at the inner structure equatorial band with detachable fasteners. Hemispheres are fabricated from a plastic honeycomb sandwich between two thin skins of fiberglass epoxy.
- Shell carries 19,152 solar cells over about 70 per cent of its surface. These semiconductors, soldered into "shingles" comprised of seven cells each, convert solar energy into electrical power to operate the electronic equipment within payload. Shingles are attached by adhesives to curved fiberglass base. This in turn is fastened to the hemispherical cover.
- Courier carries two independent sets of solar arrays. Each one charges a nickel cadmium storage battery, which permits high peak power loads. Batteries can operate inside the earth's shadow, or in a weightless environment. Power system gives Courier a predicted operating life of at least a year.
- Inside the shell, instrumentation includes five data storage tape recorders, four microwave transmitters, four microwave receivers, microwave antennas, baseboard combiner, diplexer—and spares. Circuitry is arranged on three honeycomb sandwich platforms supported by frame of welded aluminum tubing.

VIBRATION TESTING simulates launch. Cellular epoxy fiberglass hemispheres are used.



INNER STRUCTURE, aluminum frame supporting three honeycomb platforms examined.

INSIDE VAN, engineers prepare to "listen" to Courier on four receiving systems.

Industry Notes

. . . continued

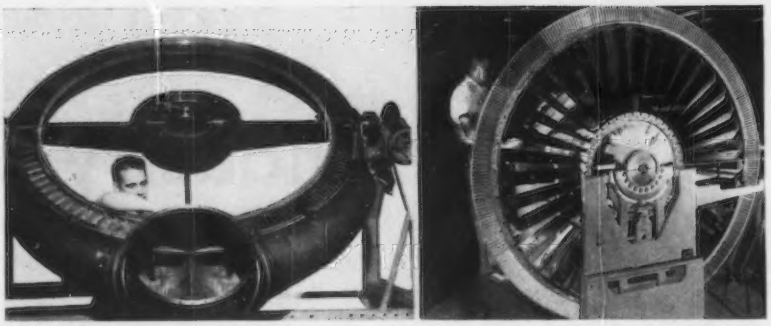
R & D Briefs

Oxygen regeneration unit is operating at Tapco Group, Thompson Ramo Wooldridge. Irradiated algae is mixed with CO_2-enriched air. The oxygen-enriched gas is then separated from the algae and sent to space cabin.

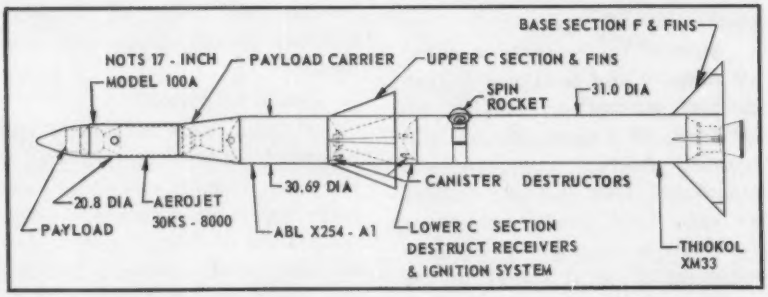
3-D tracking system at the Missile Div., Chrysler Corp., shows in color the paths of rockets, aircraft, satellites, subs. Stylus traces path through tank of gelatin.

Satellite detection system utilizing balloon-borne optical systems is under development at Electro-Optical Systems Inc. for the Air Force. Firm expects to test-fly system next summer.

Regenerative fuel cell system, under development at Tapco Group, Thompson Ramo Wooldridge, has possible applications for power generation in space.



VTOL/STOL LIFT FAN developed by General Electric's Flight Propulsion Lab has thrust-to-weight ratio of 9-to-1 when driven by J85 turbojet. Rotor, shown being balanced, functions inside "scroll" frame.

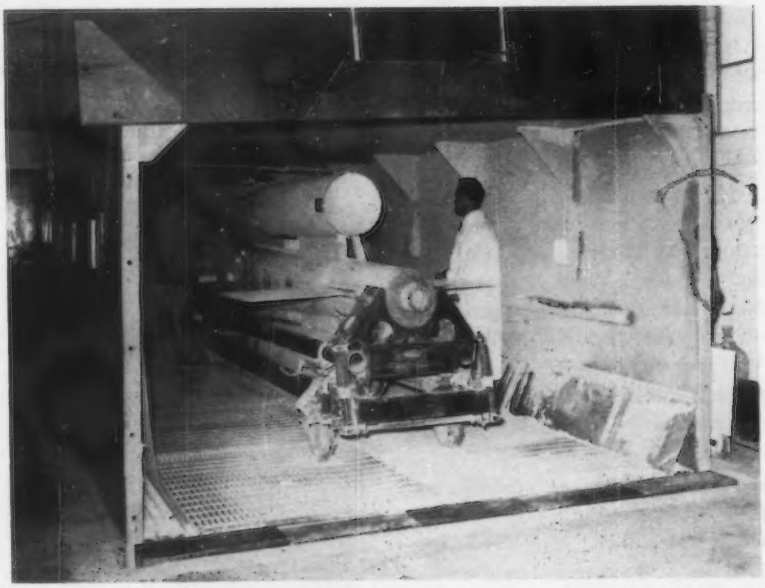


2356 CONFIGURATION is first vehicle to be launched in Air Force's Hyper-Environmental Test System 609A program for high altitude shots. It consists of four solid-propellant rocket motors. Aeronutronic is system engineer.

Production Techniques

Cold deep-drawing has been used at ACF Industries to produce a one-weld motor case consisting of two halves butted together. A prototype from the process weighed 250 lb and had 54 inch diam at the welded seam. Rolled and welded cases have two seams. ACF utilized a 4000-ton press, seven stage treating process.

Fast-responding thermocouples flush with interior surface are being used to detect gas-stream-separation phenomena in experimental nozzles for Polaris. These flat ribbon wire types can measure temps of 4800°F even while the sensing head erodes. Thermocouple material is tungsten vs. molybdenum or tungsten vs. rhenium. Erosion rates, char surface of nozzle and temp-time profiles are also obtained.



BLOODHOUND body structure meets dust-storm at Bristol Aircraft's environmental lab. Flails churn up fine quartz. This "dust" seeks out faults in joints or sealing.

Advances Reported In Brazing Tungsten

Solar Aircraft reports that it is developing braze techniques for joining tungsten at about 2000°F. This is safely below tungsten's recrystallization range. Metallurgical reactions between the metals result in a joint-filler of entirely new characteristics. The resulting braze joint does not fuse or remelt until temps approach 4000°F.

Another brazing alloy development for refractory metal fabrication involves joining massive tungsten or molybdenum to porous tungsten, molybdenum or rhenium. Special techniques prevent the brazing alloy from infiltrating the porous metal.

Application of the brazing systems: ionizer structures for use in ion propulsion devices, leading edges, wings, and fuselage of maneuverable re-entry vehicles, uncooled rocket engines.

Material Requirements For Dyna-Soar Type Re-entry Vehicles

NOSE CAP AND LEADING EDGES

1. High melting point: 6000° nose cone 4000° leading edge
2. Oxidation resistant: No catastrophic alteration for one hour at the above temperatures.
3. Erosion resistant up to 35,000 FPS.
4. Thermal shock resistant for ΔT = 100°F/sec.
5. High radiating surface: High emissivity, E—0.9.
6. Suitable attachment method.

INSULATION

1. Low thermal conductivity: 0.5 Btu-in/-ft²-°F-hr.
2. Low density: 15 lb/ft³ or less.
3. High melting point: 4000°F or higher.
4. Compression load carrying capability, 50 psi.
5. Attachment method without reducing insulative effectiveness.

SEALS

1. Resilience at service temperatures up to 3800°F.
2. Low permanent set after one hour at 2000°F.
3. Adaptability to shapes.

BEARINGS

1. Low coefficient of friction (0.1) at service temperatures (—250° to +3000°F).
2. Low wear rate—failure criterion is .0005" radial play (max.) in a 30-60 minute re-entry.
3. A retention method satisfactory over a wide temperature range (—250° to +3000°F).
4. Resistance to impact and vibration.

PRIMARY STRUCTURE AND SKIN PANELS

1. High strength-to-weight ratios at service temperatures up to 3600°F.
2. Oxidation resistant: No catastrophic alteration after 8 hrs. at 3000°F.
3. Erosion resistant up to 35,000 fps.
4. Low thermal expansion.
5. High radiating surface: High emissivity, E—0.9.
6. Weldable.
7. Suitable for attachment of mechanical fastenings.

VISION

1. High temperature glass: 2600-3600°F.
2. Low thermal conductivity: 10 Btu-in/-ft²-°F-hr or less.
3. Good light transmission: 60% visibility.
4. Reflect harmful radiation (IR and UV).
5. High strength at 2600°F temperature.
6. Suitable attachment method.

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Fluid

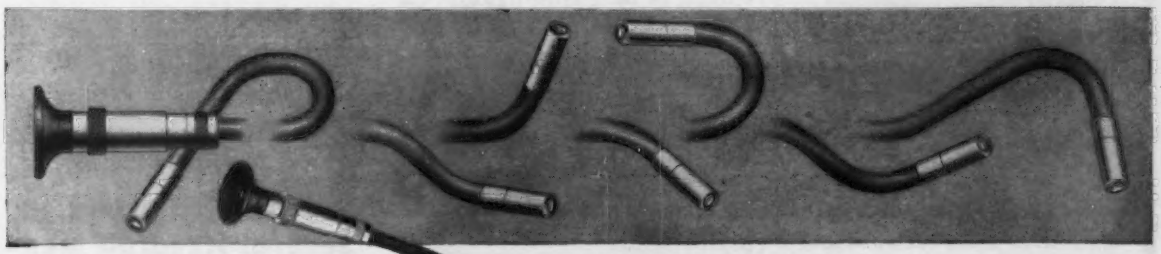
Thermally stable up to 1500°F.
Compatible with (noncorrosive to) metals and seals in system.
Good lubricant for pump-working parts.

Pump

Capable of operating at 1500°F.
Approx. 10 gal/min, 3000 psi.
No brass or bronze.

System

Completely pressurized with nitrogen to avoid oxidizing fluid.
No brass or bronze.



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FOR visualization in inaccessible curved areas where a flexible instrument capable of adapting itself to irregular contours is required.

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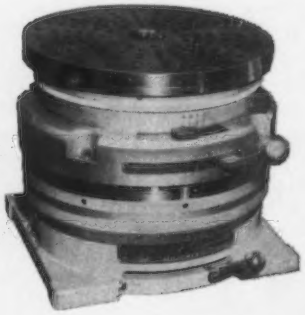
Designed to provide indexing accuracies of ¼ second of arc, Milichex tables are available in many models and combinations to fit almost any need, including angular indexing to minutes and seconds. (1,296,000 positive settings within a full circle.) "Laboratory" accuracy to within 12-millionths of an inch at a 20 inch diameter is possible.



This Model M2X-900 Milichex allows quick setting to any full or fractional angle in ¼ degree increments on a production basis. Operator merely sets tables to two marks. They automatically lock into correct setting.

All Milichex models are flat and parallel within 0.000050 inches and provided with numerous threaded holes for easy mounting of workpiece or fixtures. Milichex tables can be used also for checking roundness or concentricity within 10-millionths.

For details write for Bulletin X-60

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DETROIT 12, MICHIGAN

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Industry Notes

. . . continued

Escape System

An "Integrated Flight Capsule" is being developed by Chance Vought as an emergency escape means for single crew aircraft. It will involve actual instantaneous severance of the front section of the aircraft from the wings and rear section.

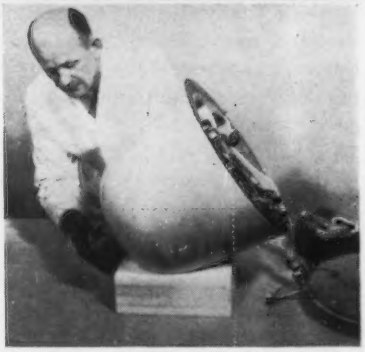
The front section or capsule containing the pilot will be equipped with stabilizing fins and auxiliary propulsion, which will provide some measure of flight control until it can be lowered to earth by parachute. Thus the pilot remains in the cockpit protected from adverse conditions of speed, altitude and flight.

Instantaneous severance is accomplished by means of Flexible Linear Shaped Charge (FLSC) developed by the Ensign-Bickford Co. This is a metal-clad explosive, processed to be "V" grooved on one

side. This groove provides a shaped-charge-effect which directs and concentrates the explosive energy.

Trial separations from F8U-1 "Crusader" aircraft have been made in air and under water.

The Navy recently accepted and approved design of a mockup of the capsule.



NERV VEHICLE used to probe inner Van Allen belt is shown on its rocket spacer (top) and by itself (below). Cylindrical disk with nuclear emulsion is exposed on surface at about 300 miles.

Satellite May Hold Several Hundred Men

NASA is studying concrete proposals for orbiting space stations holding several hundred men. These would be at least 100 ft in diam and would be orbiting within 15 years.

Preliminary design work is now underway at several large aerospace firms and will be submitted early next year. The stations, which would be assembled in orbit, may be doughnut-shaped. One proposal is for six intersecting spheres in ring shape.

Stations will probably be metallic. Plastics suffer in this case because of the out-gasing problem. Gas may leave a plastic structure if structure is placed in a large vacuum.

SPACE VEHICLES will use a great deal of sandwich structure. Aeronutronic has WADD contract to study three-man vehicle. Half-scale section shows corrugated core.

Braking the JetStar

Lockheed's JetStar is braked by friction generated in clamping alternating rotating and non-rotating disks together. Friction material is a compound consisting of iron and other metallic and non-metallic powders.

The iron compound is sintered to the surfaces of the steel disks under high temperature and pressure. This forms a strong, hard brake lining for each of the four wheels.

Lining was developed by Raybestos-Manhattan, Inc., for B. F. Goodrich, producer of the brake assembly. Lining has stopped a fully-loaded JetStar in a minimum runway distance from a speed of 175 mph. In this case, called a rejected takeoff condition, each brake must convert 8⅛ ft. lb. of kinetic energy to heat energy, then dissipate this 2000° F temp.

JetStars are being produced at Lockheed's Marietta, Ga. plant. They have the military designation of C-140; and go into Air Force operation in 1962 as jet utility craft.

Need Metals Data?

Electronic literature - searching is operating effectively in the metals field in the new American Society for Metals Documentation Service.

Current articles from more than 600 magazines around the world are continually coded—to be recalled by electronic machinery. Electronic tapes also hold abstracts of pertinent subjects from currently-published books, government reports, patents, and translations.

Subscribers pay $50 per month to receive digests on the subjects which they stipulate. Mechanized literature-searching on an industry-wide basis might save as much as $500-million a year, according to some estimates.

The literature scanning service was inaugurated this year after four years of ASM-sponsored research at Western Reserve University. It utilizes a GE-250 selector, which searches almost 40,000 digests. Other technical groups have expressed interest in establishing similar electronic information services.

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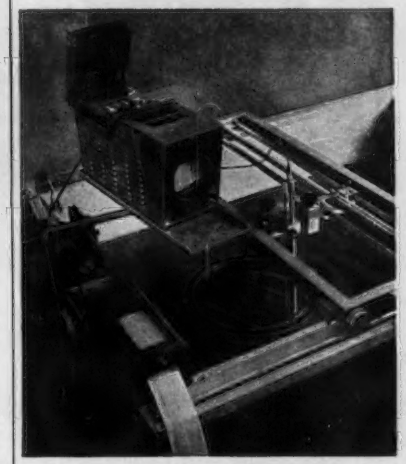
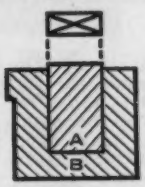
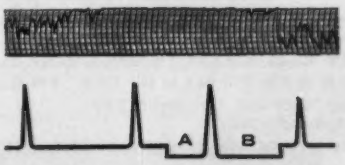


Early warning of internal defects prevents further waste of time and money on materials and parts that would later be rejected or fail in service / Here, for instance, a *Sonoray®* Ultrasonic Flaw Detector with accessory Model B *Sonogate* Flaw Alarm, immersion-scans a vital bi-metallic rotary seal. Every variation in bond between the two dissimilar materials is revealed on the CRT and strip-recorded as the part rotates on the submerged turntable / This is just one of the many DEW* techniques available with Branson Ultrasonic Flaw-Detection and Thickness-Gaging equipment. State your problem in detail when requesting further information.





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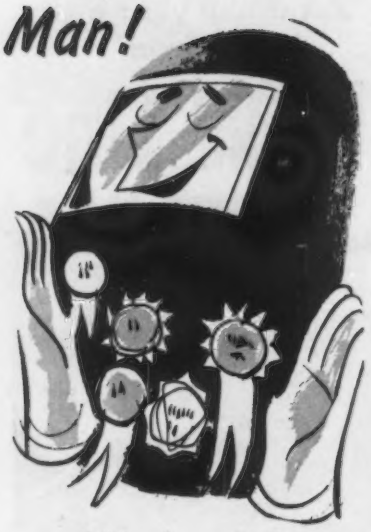

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Industry Notes

. . . continued

GTOL Concept Studied

Vertol Div. of Boeing has just received an Army contract for wind-tunnel-testing and preliminary design of a "GTOL" aircraft.

A GTOL only rises vertically a short distance from the ground before beginning forward flight. A VTOL may rise to much greater heights.

If proven feasible, the GTOL has potential for high payload capability because it eliminates landing gear and other weight factors. Power failures on some present VTOL types would be catastrophic; whereas the GTOL is conceived as having glide capability.

The present Vertol concept is believed to be a stub-winged craft. The preliminary design work will be reviewed before any detailed design work or hardware is procured.

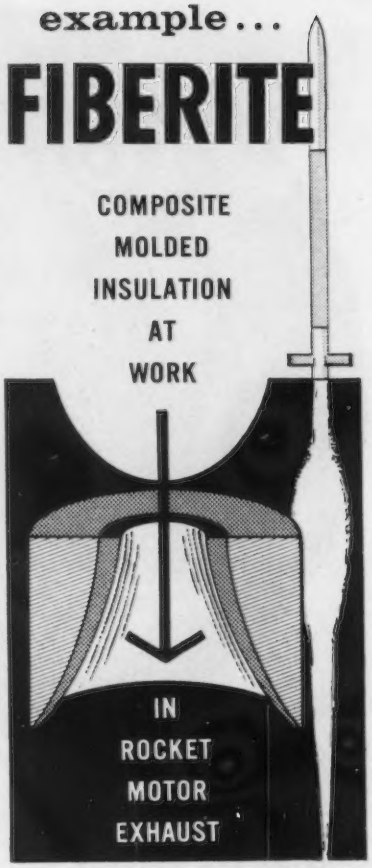
A Materials Research Programs Div. is now maintaining a continuing review of current and future national materials requirements for aerospace. This office will establish areas of NASA—funded research. Director is George C. Deutsch, 1520 H. St. NW, Washington 25, D. C.

BULLPUP B FORGING? This turbine shaft forging at Wyman-Gordon Co. would reportedly go into advanced Bullpup. Forging weighs 233 lb and was pre-heated to 1900°F.

example...

FIBERITE

COMPOSITE MOLDED INSULATION AT WORK IN ROCKET MOTOR EXHAUST



Minimum erosion and ablation resistance are needed in exit areas to resist over 5000° F. and high velocities. Excellent results were achieved with Fiberite MX 2630 and MX 2630A. The mechanical strength and thermal insulation were provided by Fiberite MX 2625 with 2630 giving the ablation resistance. By molding these two formulations into a composite structure a superior insulation was developed.

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Missile engineers will find our research helpful in solving problems requiring materials for special performance. Write factory for bulletin "Fiberite High Temperature Insulating Materials."

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Impressor

PORTABLE HARDNESS TESTER

- Rapid testing—no setup
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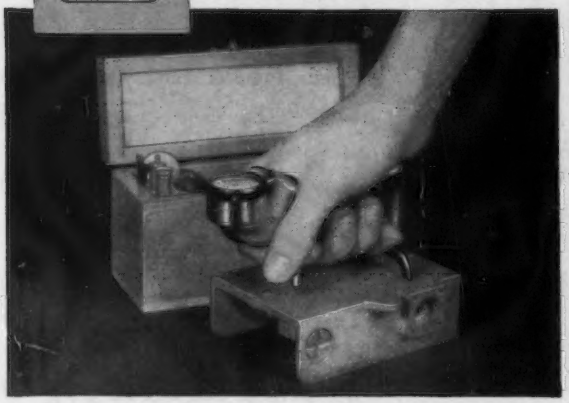

A portable hardness tester for aluminum alloys, soft metals, and plastics, the Barber-Colman Impressor is designed for fabricated parts and raw stock testing. Operating experience is not essential. The reading is instantly indicated on the convenient dial. No waiting, preloading, or separate measurements. Barber-Colman engineers will gladly recommend the most suitable model for your application. Write today for complete details.

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Flexible Joints for Handling Liquid Oxygen

and other missile fuels

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Patent Pending

(Right) 6"—180° Flanged Barco Flexible Joint for use in fueling line handling liquid propellant. Also straight and 90° designs.

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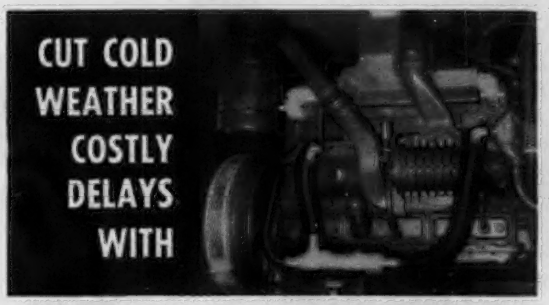

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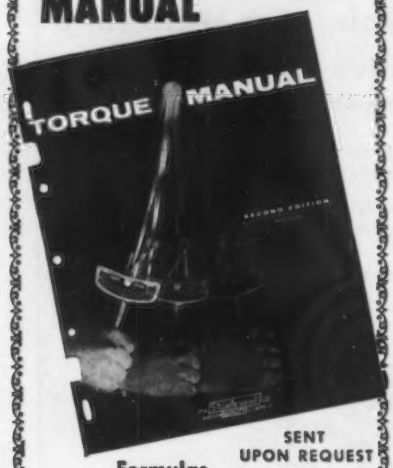

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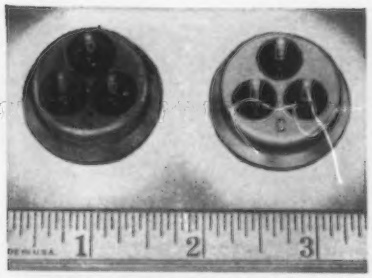

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AMP Inc.	1
Acton Labs. Inc.	73
Airetool Manufacturing Co.	73
Aluminum Co. of America	8
American Cystoscope Makers	77
Barber-Colman Co.	81
Barco Mfg. Co.	81
Bendix Corp. Red Bank Div.	55
Boeing Airplane Co.	45
Boeing Airplane Co., Transport Div.	27
Branson Instruments, Inc.	79
Brunswick-Balke-Collender Co.	Back Cover
Bulova Research & Dev. Lab., Inc.	70
Dow Corning Corp.	66
E. I. duPont deNemours & Co.	4
Elastic Stop Nut Corp. of America	81
Fiberite Corp.	80
Garrett Corp., AiResearch Mfg. Div.	33
General Electric Co., Flight Propulsion Div.	64
Hansen Mfg. Co.	15
Hercules Powder Co.	20
Huck Mfg. Co.	6
Ideal Industries, Inc.	60
James, Pond & Clark, Inc.	66
Jamesbury Corp.	3rd Cover
Kelsey-Hayes Co.	16
Kim Hotstart Co.	81
Lee Co., The	9
Lepel High Frequency Lab.	7
Matthews & Co., Jas. H.	3
Mercury Air Parts Co.	82
Michigan Tool Co.	78
Midget Louver Co.	72
Miniature Precision Bearings, Inc.	42
Mystik Adhesive Prod.	42
Presray Corp.	65
Pure Carbonic Co.	26
Rodney Metals, Inc.	69
Semicon of California, Inc.	42
Simmons Fasteners	10
Special Screw Products Co.	60
Sturtevant Co., P. A.	82
Synchro-Start Products, Inc.	74
Taylor Fibre Co.	50
Technique Associates	60
Tinius Olsen Testing Machine Co.	42
Turco Products Inc.	63
Vapor Blast Mfg. Co.	82
Victor Equipment Co.	36
Vinson Mfg. Co., J. K.	2nd Cover
Wall Tube & Metal Products Co.	68
Washington Steel Corp.	71
Weller Electric Corp.	62
Western Alloy Engrg. Co., Inc.	80
White Industrial Div., S. S.	67

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19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108
109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126
127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144
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163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180

For the following numbers pertaining to recruitment please use home address.

201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220

IMPORTANT MUST INFORMATION

YOUR NAME .....TITLE .....

COMPANY .....

PLANT ADDRESS .....

CITY .....ZONE.....STATE.....

Please check in A & B below (one each) which best describes:

A. Your Job Function

....1. Management
....2. Design & Engineering
....3. Production
....4. Procurement

B. Type of Plant or Facility

....1. Airframe
....2. Propulsion
....3. Electronic Systems & Parts
....4. Mechanical Systems & Parts
....5. Raw & Processed Material
6. Engineering & Research Services Facilities
....7. Military & Government
....8. Parts & Supplies
....9. Plant or Test Equipment
....0. Other

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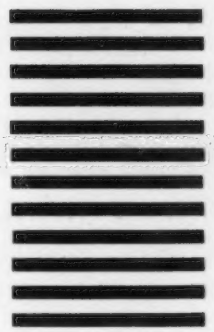

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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
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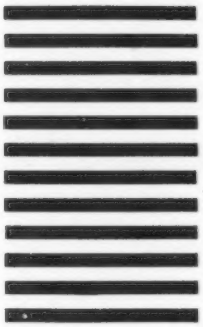

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- Advertisers' Services
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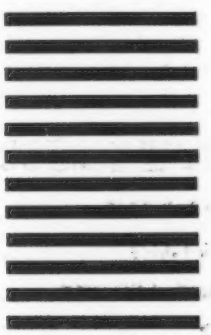


Before Buying Any Valve

ASK THESE QUESTIONS

1. Will It Perform More Effectively In The Service?
2. Where Will It Save Money?
3. How Practical Is The Design?

jamesbury

"Double-Seal"™

BALL VALVES*

As Versatile As Industry Itself!

PROVIDE THE RIGHT ANSWERS

1. The "Double-Seal" Ball Valve has PROVED more effective in handling a wider range of liquids and gases than any other valve.
2. The "Double-Seal" Ball Valve requires no lubrication. Special design permits valve stem to be removed for repacking while valve remains in line full-open or full-closed. Resulting savings on maintenance are significant.
3. The "Double-Seal" Ball Valve design is the original ball valve design engineered to give more control, full pipeline capacity and minimum friction loss.

JAMESBURY CORP., Worcester, Mass.

Distributors in Principal Cities

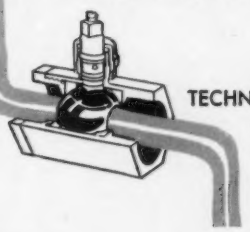
Widest Range of Sizes and Materials Available

METAL VALVES		PLASTIC VALVES	
TYPE	SIZES	TYPE	SIZES
Screwed End	¼" thru 3"	Screwed End	½" thru 3"
Flanged	½" thru 10"	Flanged	½" thru 4"

Jamesbury "Double-Seal" Ball Valves are available in Types 303, 316 and Alloy 20 Stainless Steels, Carbon Steel, Bronze, Ductile Iron, Aluminum and PVC. Other materials on special order.

Interchangeable seats and seals are available in "Teflon", Nylon, Buna-N, Neoprene, Hypalon and natural rubbers.

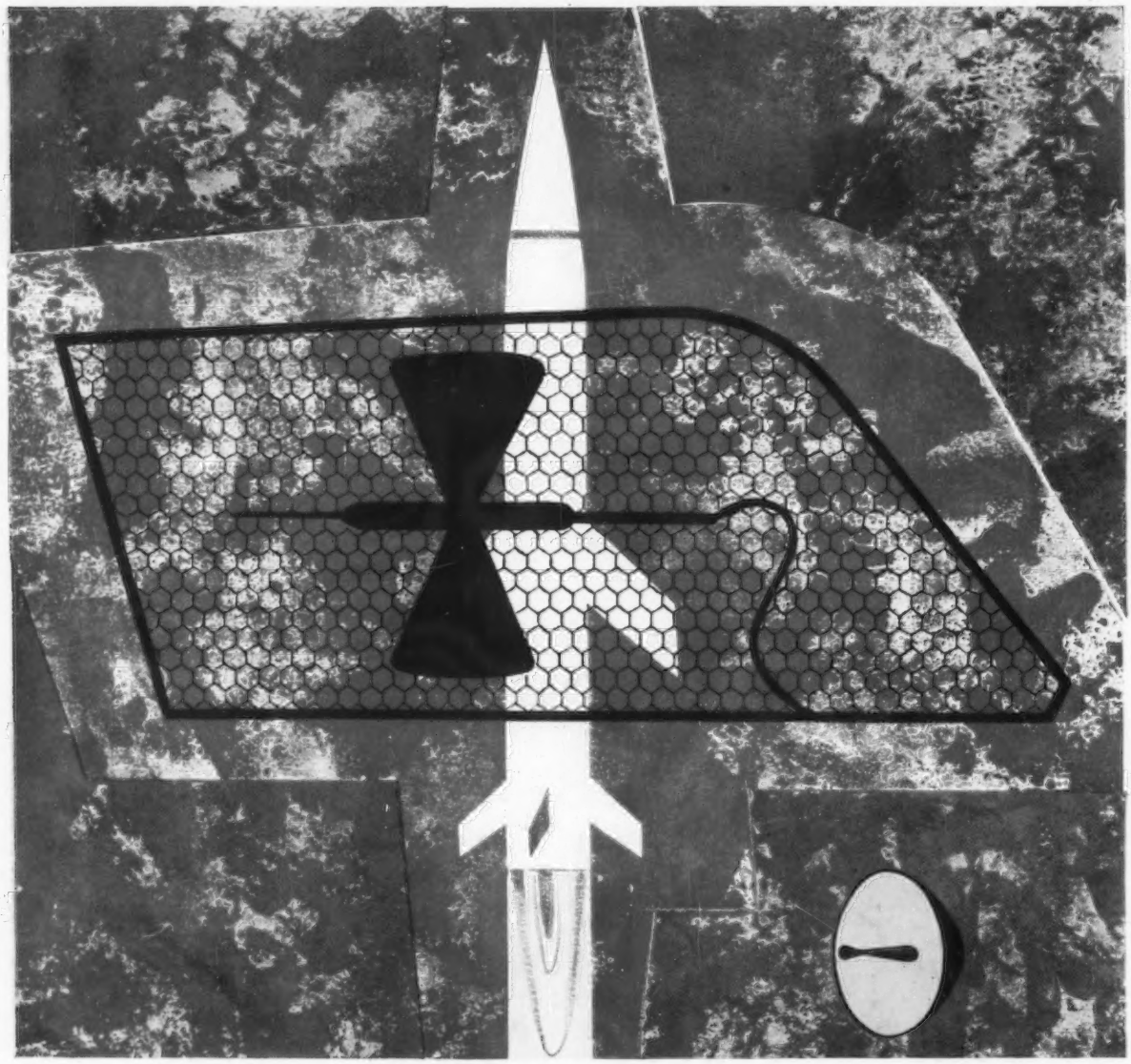
Pneumatic, Hydraulic and Electric Motor Operators to fit Remote Control Requirements.



COMPLETE TECHNICAL INFORMATION ON REQUEST

* PATENTED

Circle 2 on Inquiry Card



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Our design engineers are now totally integrating all communications, telemetry and navigational antennas and reflectors within primary structures. Already fully tested and in actual use, these plastic (honeycomb and foam sandwich; solid laminated) primary structures with plastic skins do not interfere with reception or transmission units hidden inside. All-plastic fins, wing tips and other assemblies for aircraft and missiles give a highly efficient weight-strength ratio, while providing aerodynamically clean lines that are unbroken by stubs or ports. The marriage of plastics and antennas is a capability developed and advanced by Brunswick as a result of many years experience with aircraft and missile problems. For every new primary structure problem, Brunswick draws on its vast reservoir of knowledge gained through this experience. Brunswick can not only construct entire, integrated units, but can provide complete in-house design and testing for unique components that will meet the most rigid specifications. Can Brunswick help you? Investigate! Take time right now to call or write: The Brunswick-Balke-Collender Company, Defense Division Sales Manager, 1700 Messler Street, Muskegon, Michigan.

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